LATEST TOARCIAN AMMONOIDS FROM THE NORTH AMERICAN CORDILLERA

by GISELLE K. JAKOBS *and* PAUL L. SMITH

ABSTRACT. Latest Toarcian (Early Jurassic) strata crop out in southern Alaska, southern Yukon, British Columbia, south-western Alberta, and eastern Oregon. Work in the Queen Charlotte Islands, British Columbia has proved a relatively complete Toarcian sequence which has provided the basis for a North American Toarcian ammonite zonation. The Upper Toarcian Yakounensis Zone is characterized by a diverse ammonite fauna, previously assigned to the Middle Toarcian. Species of *Hammatoceras*, *Dumortieria*, *Sphaerocoeloceras*, *Pleydellia*, *Holcophylloceras*, and *Pseudolioceras* allow correlation with the younger part of the Levesquei Zone of north-west Europe. The new genus *Yakounia* and seven new species (*Yakounia yakounensis*, *Y. pacifica*, *Y. freboldi*, *Y. silvae*, *Pleydellia maudensis*, *P. crassiornata* and *Dumortieria*? *phantasma*) are introduced, all of which are endemic to western North America. A global regression during the Late Toarcian may have restricted migration between the eastern Pacific and western Tethys resulting in the development of endemic taxa.

WESTERN North America is a tectonically complex area made up of numerous accreted terranes (Text-fig. 1). These are commonly fault-bounded regions and each appears to have a separate and distinct geological history. Palaeomagnetic and palaeontological evidence suggests that some terranes may have undergone significant latitudinal displacement since the Jurassic (Irving *et al.* 1980; Taylor *et al.* 1984; Smith and Tipper 1986; Irving and Yole 1987; Irving and Wynne 1991). Understanding this complex history requires correlation within and between terranes, and between the terranes and the craton. To date, Toarcian strata in western North America have been recognized from Alaska to Oregon, both on the craton (southern Canadian Rocky Mountains) and in the following terranes: Peninsular, Stikine (Stikinia), Quesnel (Quesnellia), Wrangell (Wrangellia), Izee (in Oregon), as well as in several small slivers in south-western British Columbia (Text-figs 1–2).

Previous ammonite workers (Frebold 1957, 1964*a*, 1964*b*, 1969, 1976; Frebold *et al.* 1967, 1969; Imlay 1968, 1981; Frebold and Tipper 1970) had difficulty interpreting the Toarcian succession of western North America because of the complex geology of the Cordillera and the lack of stratigraphical sections. They relied on the north-west European zonation and compared the North American fauna with common north-west European taxa. However, work on the Early Jurassic of the Americas has shown consistently that eastern Pacific faunas have closer affinities with Tethyan faunas, contain endemic Pacific species, lack certain European elements, and may have different age ranges for common taxa. For example, a re-assessment of some older collections previously assigned to the Middle Toarcian based on the supposed presence of *Haugia* (Frebold 1976; Imlay 1981), indicates that they are in fact of latest Toarcian age, as had been suggested tentatively by Hall (1987). This latest Toarcian fauna includes *Hammatoceras*, *Sphaerocoeloceras*, *Dumortieria*, *Pleydellia*, and a new genus of the Phymatoceratinae; the genus *Haugia* does not occur along the Pacific rim. Such observations clearly point to the need for a regional zonation. A significant step in this direction has been the discovery of a relatively complete Toarcian succession in the Queen Charlotte Islands, British Columbia (Text-fig. 2; Jakobs 1992; Jakobs *et al.* 1994, 1995). The purpose of this paper is to review the distribution of Late Toarcian rocks in North America, and to describe the latest Toarcian ammonites from successions that form the basis of a North American ammonite zonation.

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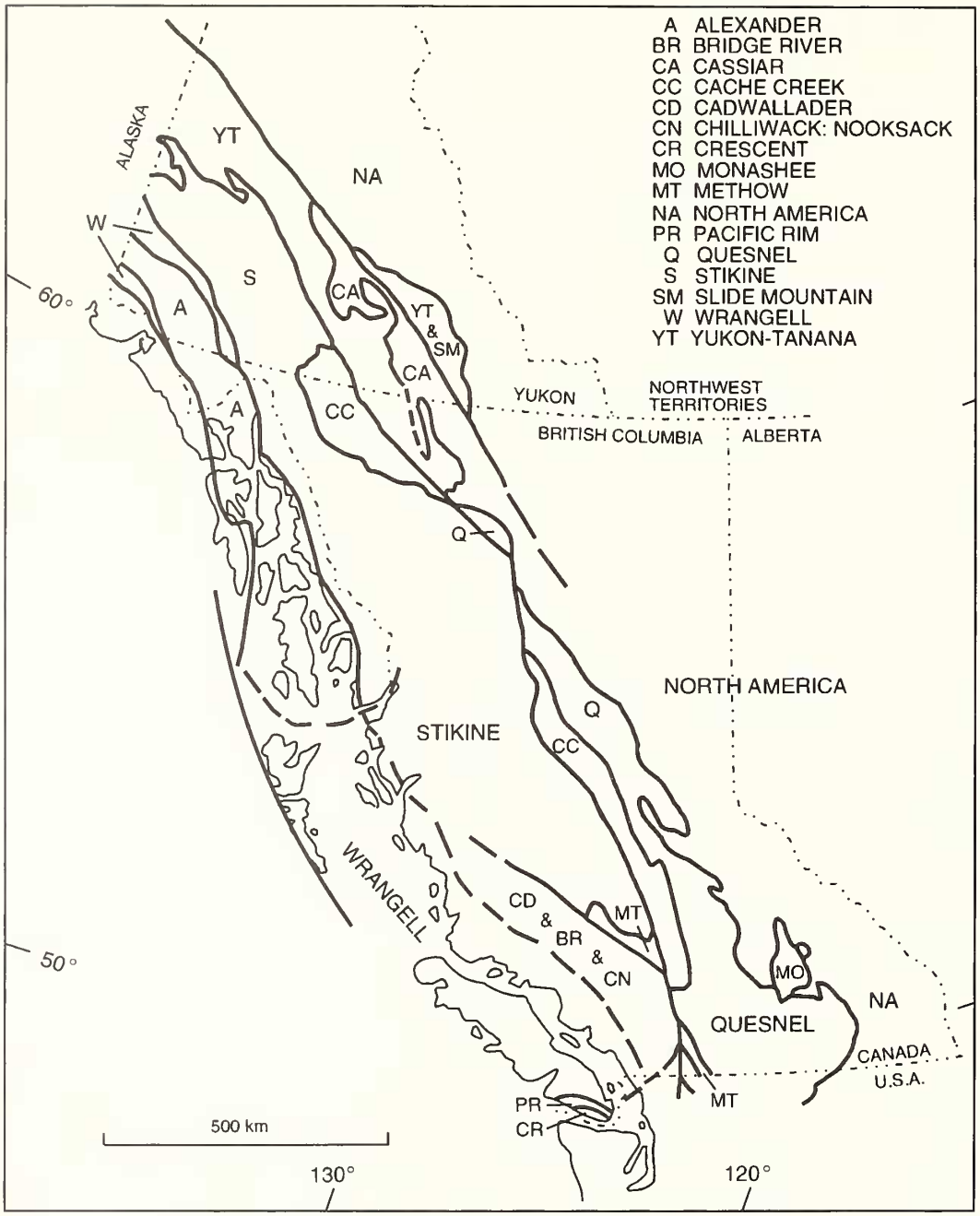
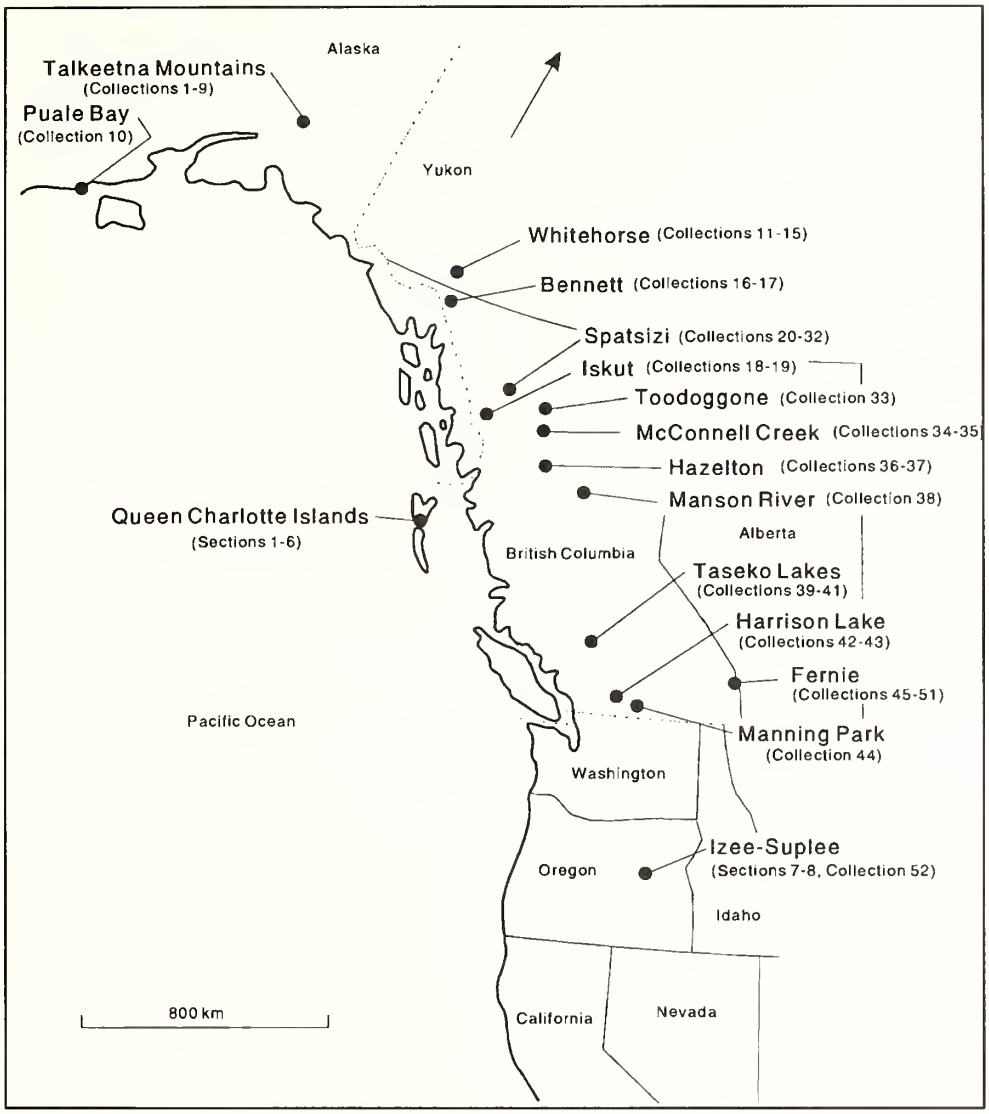


TEXT-FIG. 1. Generalized terrane map of the Canadian Cordillera.

UPPER TOARCIAN ZONES OF NORTH AMERICA

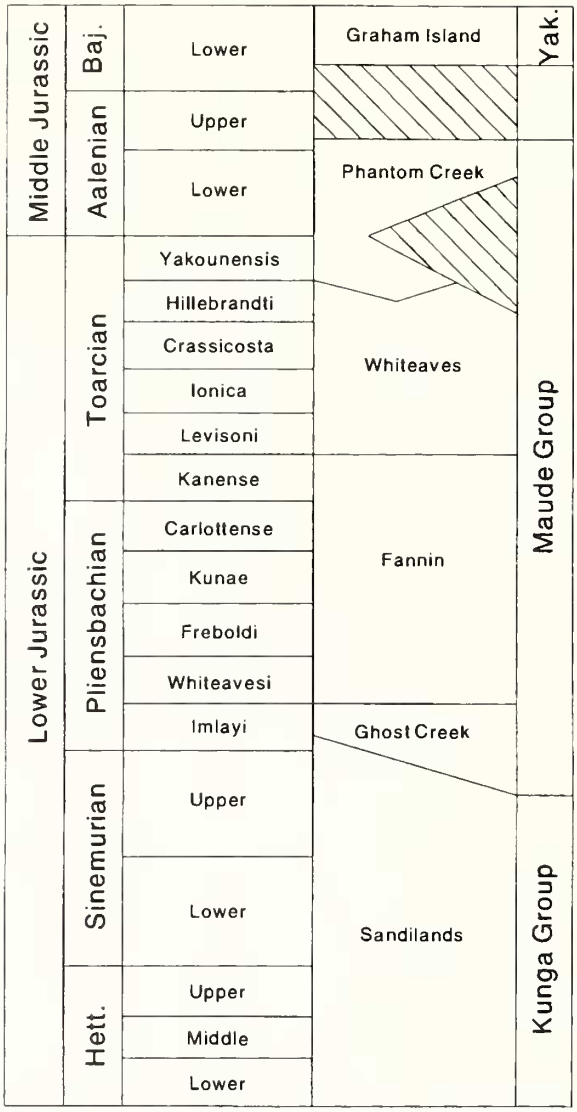
The two Upper Toarcian ammonite zones detailed below were outlined by Jakobs *et al.* (1995), and have been formally described by Jakobs *et al.* (1994).



TEXT-FIG. 2. Map showing Upper Toarcian localities in western North America. The biostratigraphy of sections 1–8 is shown in Text-figures 7–14. Locality data and faunal listings for Collections 1–52 are available from the British Library as Supplementary Publication No. SUP 14044.

Hillebrandti Zone

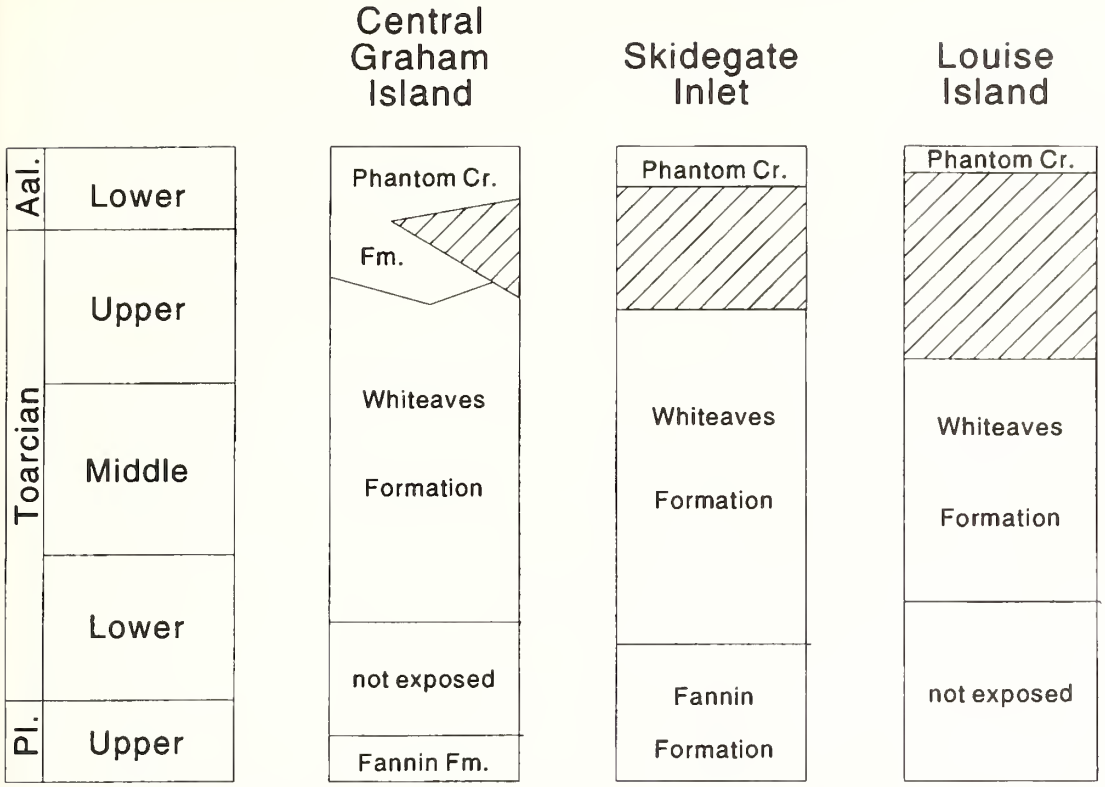
This zone (Zone 5 of Jakobs *et al.* 1995) contains a prolific, albeit low diversity fauna that includes *Phymatoceras hillebrandti* Jakobs, 1994, *Podagrosites latescens* (Simpson, 1834), and *Grammoceras thouarsense* (d'Orbigny, 1843). The Hillebrandti Zone correlates roughly with the Thouarsense Zone of north-west Europe, based on the occurrence of *Grammoceras thouarsense* and *Podagrosites latescens*, and correlates with the Copiapense Zone of South America based on the similarity between *Phymatoceras copiapense* (Moericke, 1894) and *P. hillebrandti*.



TEXT-FIG. 3. Lower Jurassic stratigraphy of the Queen Charlotte Islands. Hett., Hettangian; Baj., Bajocian; Yak., Yakoun Group.

Yakounensis Zone

This zone (Zones 5a and 6 of Jakobs *et al.* 1995) is widespread in western North America, being recognized in southern Alaska, Stikinia, Wrangellia, Quesnellia, south-western British Columbia, Oregon, and on the craton. The interval is thin and stratigraphical relationships between the different species are sometimes difficult to establish. The diverse fauna includes *Pleydellia maudensis* sp. nov., *Pl. crassiornata* sp. nov., *Pl. aalensis* (Zieten, 1832), *Yakounia yakounensis* gen. et sp. nov., *Y. freboldi* sp. nov., *Y. pacifica* sp. nov., *Y. silvae* sp. nov., *Sphaerocoeloceras brochiiforme* Jaworski, 1926, *Hammatoceras speciosum* Janensch, 1902, *Dumortieria insignisimilis* (Brauns, 1865), *D. raricostata* Géczy, 1967, *D. exacta* Buckman, 1905, *D.* cf. *dumortieri* Thiollière *in* Dumortier, 1874, *D.*? cf. *pusilla* Jaworski, 1926, *D.*? *phantasma* sp. nov., *Pseudolioceras compactile* (Simpson, 1855)



TEXT-FIG. 4. Extent of the Toarcian/Aalenian hiatus in the Queen Charlotte Islands. Pl. Pliensbachian; Aal., Aalenian.

and *Holcophylloceras calypso* (d'Orbigny, 1841). It contains several taxa endemic to North America and the eastern Pacific.

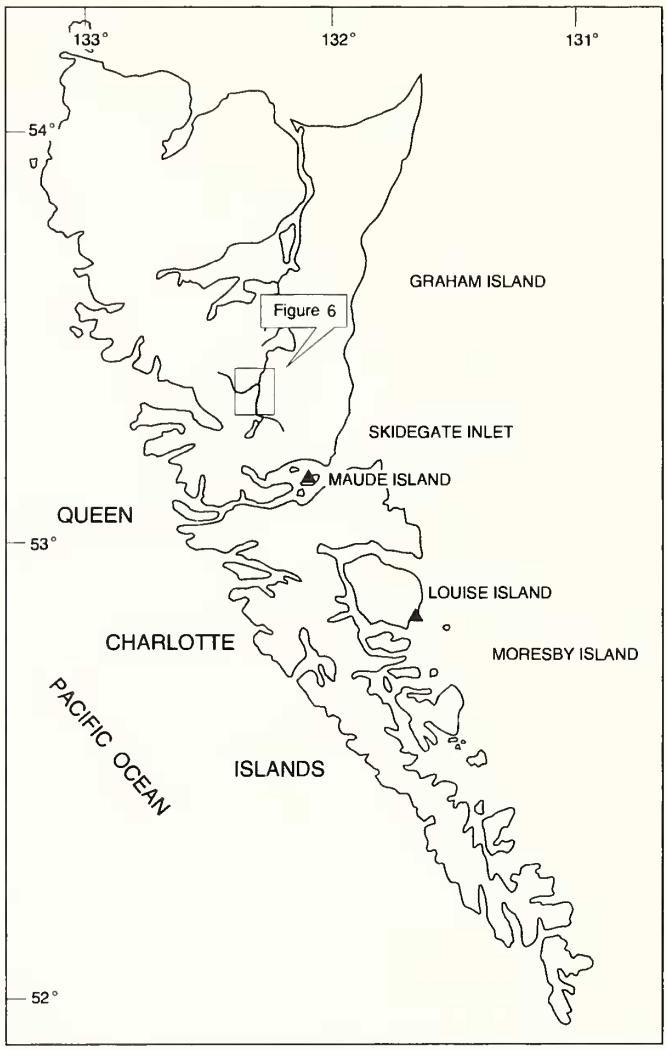
Both Frebold (1976) and Imlay (1981) assigned this interval to the Middle Toarcian based on the erroneous recognition of *Haugia* (in fact, specimens of *Pleydellia* and *Yakounia*, a new genus endemic to western North America). A rough correlation can be made with the '*Pleydellia fluitans*' and '*Pleydellia lotharingica*' zones of South America, based on the co-occurrence of *Sphaerocoeloceras brochiiforme*, *Dumortieria* cf. *pusilla*, and species of *Pleydellia*. Both *Pleydellia lotharingica* (Branco, 1879) and *Pliyseograunnoceras*? *tenuicostatum* (Jaworski, 1926) are similar to *Pleydellia maudeusis* which spans the Yakouensis Zone. According to Poulton and Tipper (1991), the base of the Aalenian Stage in North America is defined by the first appearance of *Tmetoceras scissum* (Benecke, 1865). Although *T. scissum* is abundant above the Yakounensis Zone fauna in east-central Oregon, only a single specimen of *Tmetoceras* has been collected from central Graham Island in the Queen Charlotte Islands, the Aalenian there being more commonly characterized by species of *Planammatoceras*, *Bredyia*, and *Erycitoides*.

OCCURRENCES OF LATE TOARCIAN STRATA IN NORTH AMERICA

Queen Charlotte Islands, British Columbia

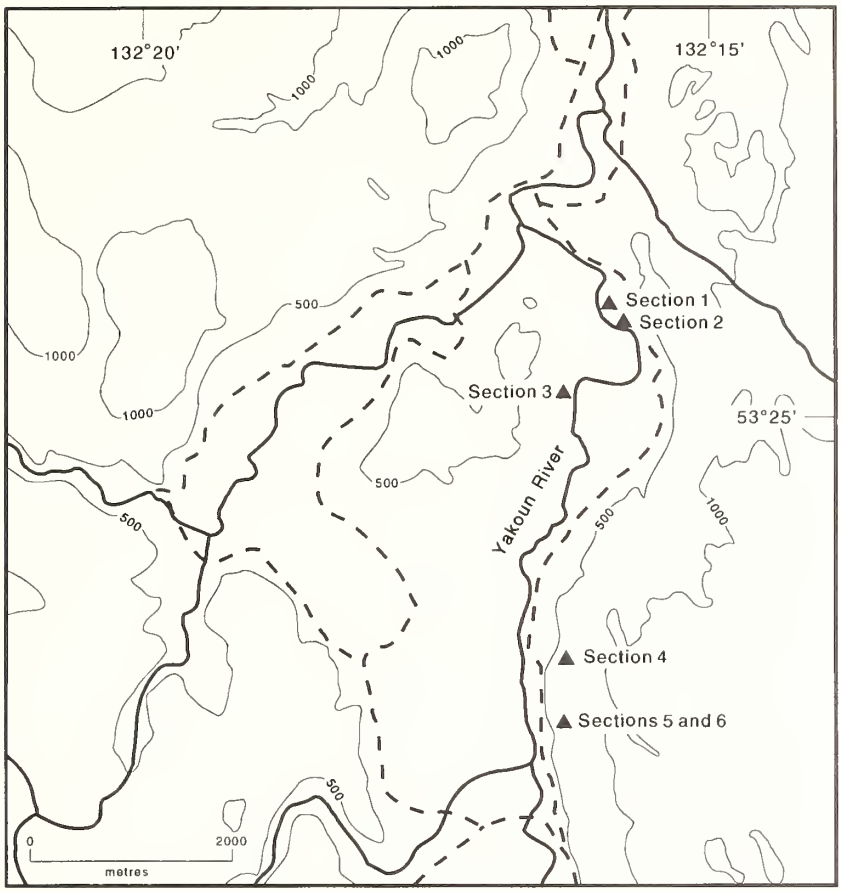
Mesozoic strata in the Queen Charlotte Islands include the most complete marine Lower Jurassic depositional sequence in North America (Sutherland Brown 1968; Cameron and Tipper 1985; Jakobs 1990; Tipper *et al.* 1991) (Text-fig. 3). Toarcian strata of the Maude Group are represented by the Fannin, Whiteaves and Phantom Creek formations.

The Whiteaves Formation is a grey-green siltstone, weathering brown-grey, which is recessive and commonly poorly exposed in road and stream cuts in central Graham Island, the Skidegate Inlet area and on Louise Island (Text-fig. 5). Neither bedding nor lamination were observed in the siltstones but sandy layers occur at intervals. The siltstones are rich in pyrite and glauconite; ash layers and buff-weathering, calcareous concretions are common. The contact with the overlying Phantom Creek Formation is conformable on much of Graham Island, whereas a hiatus is probably present on Maude island (Skidegate Inlet) and Louise Island (Text-fig. 4).



TEXT-FIG. 5. Toarcian localities in the Queen Charlotte Islands.

The Phantom Creek Formation is a resistant sandstone unit exposed in stream and road cuts. It is best exposed in central Graham Island where it is 25 m thick. Thin (< 2 m) sequences crop out on Maude Island and Louise Island. The formation can be subdivided into two units, a lower

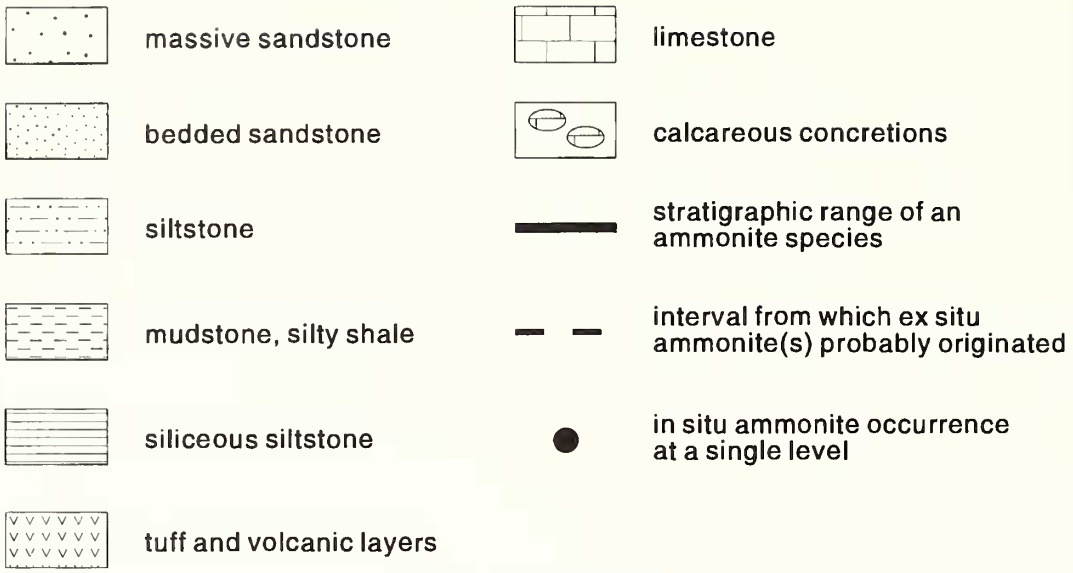


TEXT-FIG. 6. Location of Upper Toarcian sections in central Graham Island, Queen Charlotte Islands.

Coquinoid Sandstone Member and an upper Belemnite Sandstone Member (Cameron and Tipper 1985); these are separated by an erosional hiatus that increases in magnitude toward the south (Text-fig. 4). In central Graham Island, the two members are conformable at Sections 1–3 (Text-figs 5–6), with a cumulative thickness of over 25 m, but at Sections 5 and 6, the Coquinoid Sandstone Member is absent. At Maude Island, Skidegate Inlet, the Coquinoid Sandstone Member is also absent, and a thin (2–3 m) layer of the Belemnite Sandstone Member separates the Whiteaves Formation from the overlying Yakoun Group. The contact between the Phantom Creek Formation and the overlying Yakoun Group is an angular unconformity, best exposed in central Graham Island.

Southern Alaska

In the Talkeetna Mountains (Text-fig. 2), Early Jurassic strata are represented by the Upper Sinemurian to Upper Toarcian Talkeetna Formation, a thick (4600–5800 m) unit of volcanic and volcaniclastic rocks deposited in a marine to non-marine environment (Imlay 1981). Imlay (1981) identified a Middle Toarcian fauna from the Talkeetna Mountains which he assigned to the



Key for Text-figures 7–14.

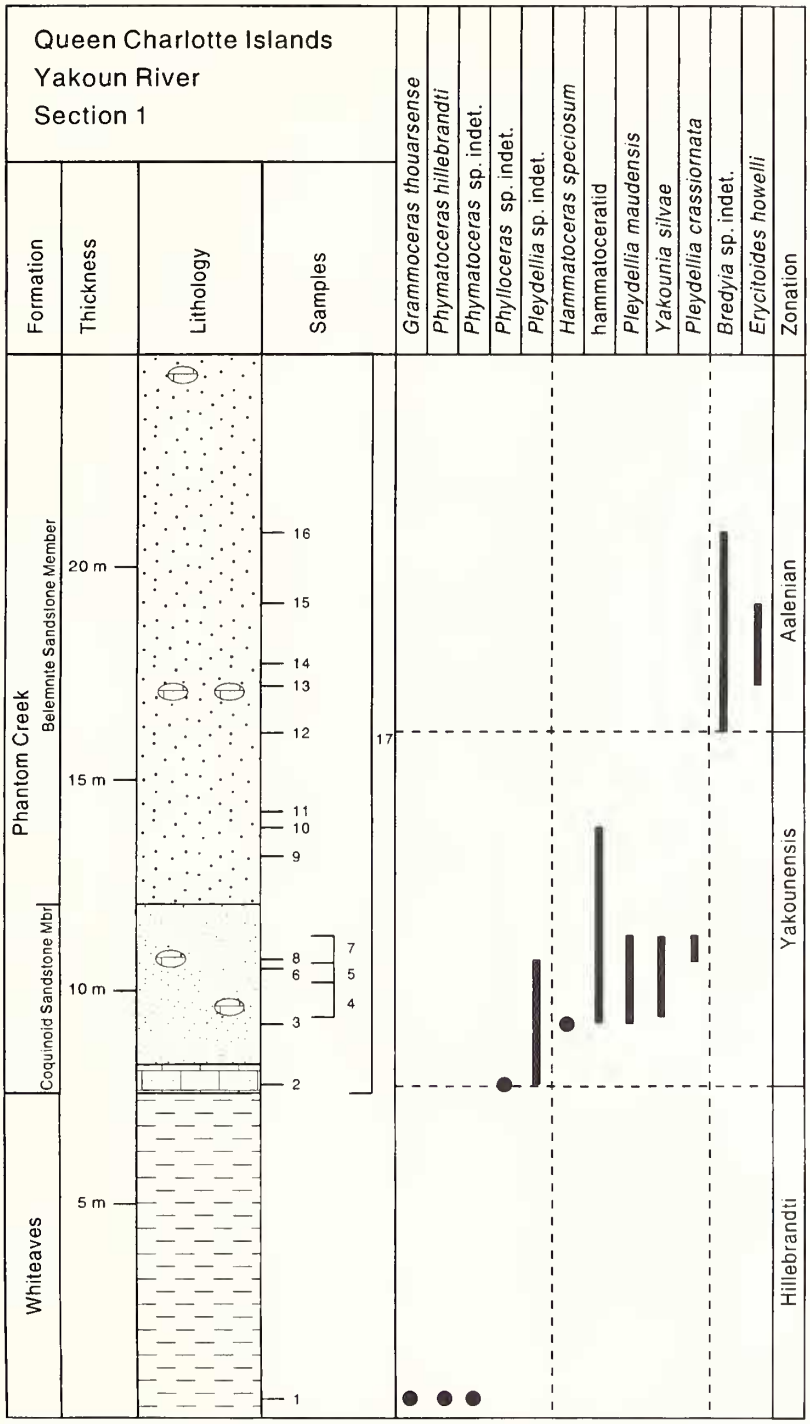
north-west European Variabilis Zone. Recent work in the Queen Charlotte Islands has shown that the Alaskan fauna is identical to the Late Toarcian Yakounensis Zone assemblage from the Queen Charlotte Islands and contains *Hammatoceras* sp. indet. (= *Plymatoceras*? sp. of Imlay (1981)), *Yakounia yakounensis* (= *Haugia* cf. *variabilis* (d'Orbigny, 1842) of Imlay (1981)), *Pleydellia maudensis* (= *Haugia* cf. *grandis* Buckman, 1898 and *Haugia* cf. *compressa* Buckman, 1898 of Imlay (1981)), *Pleydellia* sp. indet. (= *Brodieia* cf. *tenuicostatum* var. *nodosa* and probably *Haugia* sp. of Imlay (1981)), and *Pseudolioceras* sp. indet. (Collections 1–9).

A small section of Jurassic strata exposed at Puale Bay (Text-fig. 2) includes the Upper Toarcian to Lower Bajocian Kialagvik Formation, a dark grey to black, sandy siltstone containing some hard, buff sandstone (Imlay 1981). Imlay (1981) assigned a single collection to the Middle Toarcian, Variabilis Zone. The fauna is identical to that from the Talkeetna Mountains and Queen Charlotte Islands and contains *Pleydellia maudensis* (= *Haugia* cf. *compressa* of Imlay (1981)), *Pl.* sp. indet. (= *Haugia* cf. *grandis* of Imlay (1981)), and *Pseudolioceras* sp. indet. (Collection 10).

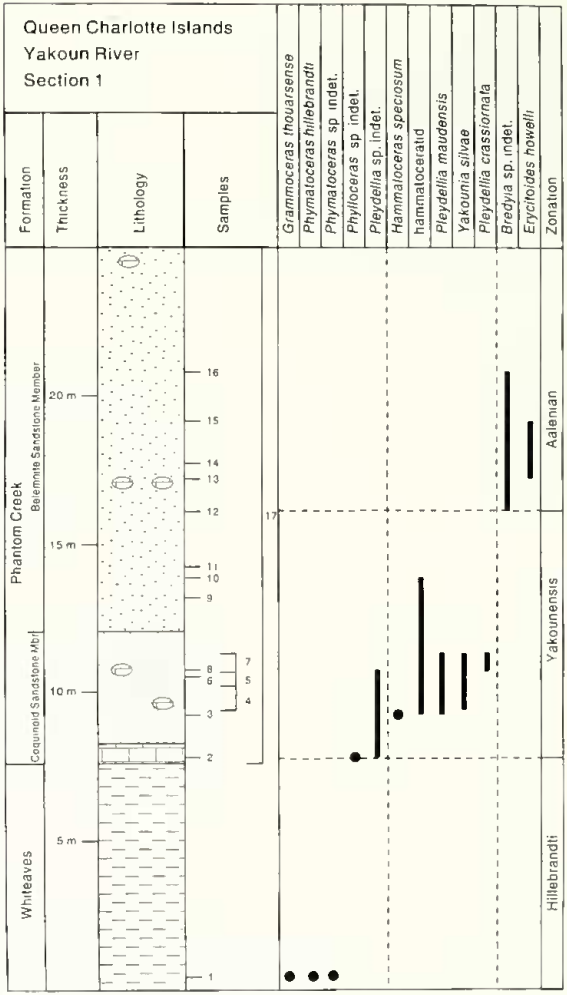
Northern Stikine Terrane

In the northern part of the Stikine Terrane, sediments of the Lower to Middle Jurassic Laberge Group have yielded Late Toarcian ammonites. Two facies were recognized by Souther (1971): the coarse-grained, near-shore Takwahoni Formation in the south-west; and the argillaceous, basinal Inklin Formation in the north-east. Toarcian fossils occur in the former and possibly in the latter (H. W. Tipper, pers. comm. 1992).

Late Toarcian ammonites identified by Frebold (1964*a*) from the Whitehorse area, southern Yukon (Text-fig. 2; Collections 12–15) include *Catulloceras*? (probably a *Dumortieria*), *Dumortieria*?, and *Harpoceras*? (probably a *Pseudolioceras*). A poorly preserved specimen of *Yakounia*? sp. indet. has also been identified (Collection 11). The reported *Grammoceras* aff. *G. fallaciosum* (Bayle, 1878) and *Grammoceras*? *boreale* (Whiteaves, 1889) (Frebold 1964*a*, p. 17, pl. 7, figs 1–4) are actually Middle Jurassic forms (Poulton and Tipper 1991; D. G. Taylor, pers. comm. 1991). Frebold (1964*a*, p. 4) mentioned the presence of *Catulloceras*? sp. indet. (= *Dumortieria* cf. *dumortieri*) from the Bennett area (Text-fig. 2; Collections 16–17).



TEXT-FIG. 7. Biostratigraphy of Section 1 (Latitude 53° 25′ 20″ N, Longitude 132° 15′ 45″ W) along the Yakoun River, Queen Charlotte Islands.



TEXT-FIG. 7. Biostratigraphy of Section 1 (Latitude 53° 25' 20" N, Longitude 132° 15' 45" W) along the Yakoun River, Queen Charlotte Islands.

Central Stikine Terrane

Along the west-central margin of the Stikine Terrane, interbedded sediments and volcanics of the Triassic to Middle Jurassic Hazelton Group have yielded Late Toarcian ammonites. In the Iskut area, the Hazelton Group has been divided into four formations: the volcanogenic Unuk River, Betty Creek, and Mount Dilworth formations, overlain by sediments of the Salmon River Formation (Anderson and Thorkelson 1990). The Salmon River Formation in the Iskut area (Text-fig. 2) has yielded several collections of *Pleydellia* cf. maudensis from the Yakounensis Zone (Collections 18–19).

In the Spatsizi area, along the northern margin of the Bowser Basin, sedimentary rocks of the Lower to Middle Jurassic Spatsizi Group have been divided into five formations of which the Melisson Formation is probably Late Toarcian in age (Thomson *et al.* 1986). Isolated localities in the Spatsizi area (Text-fig. 2) have yielded *Pleydellia maudensis*, *Yakounia yakounensis*, *Y.* sp. indet., *Dumortieria*? cf. *pusilla*, *Dumortieria* sp. indet., and *Hammatoceras* sp. indet. (Collections 20–32).

A collection of Toarcian ammonites in volcaniclastic sediments from the Toodoggone area (Text-fig. 2) has yielded *Pleydellia* sp. indet. and *Podagrosites*? sp. indet. (Collection 33).

In the McConnell Creek area (Text-fig. 2), along the eastern margin of the Bowser Basin, Lower to Middle Jurassic sediments of the Hazelton Group have yielded isolated collections of Late Toarcian ammonites (Tipper and Richards 1976) from the Smithers Formation, a unit of interbedded, shallow marine volcaniclastic sediments. Poorly preserved specimens of *Dumortieria* sp. indet. and *Yakounia yakounensis* have been collected from the Yakounensis Zone (Collections 34–35).

Toarcian ammonites occur at isolated localities in the Hazelton area (Text-fig. 2). Two collections in the Hazelton Group yielded *Pleydellia* cf. *maudensis* and *Dumortieria* sp. indet. (Collections 36–37) from the Yakounensis Zone.

Quesnel Terrane

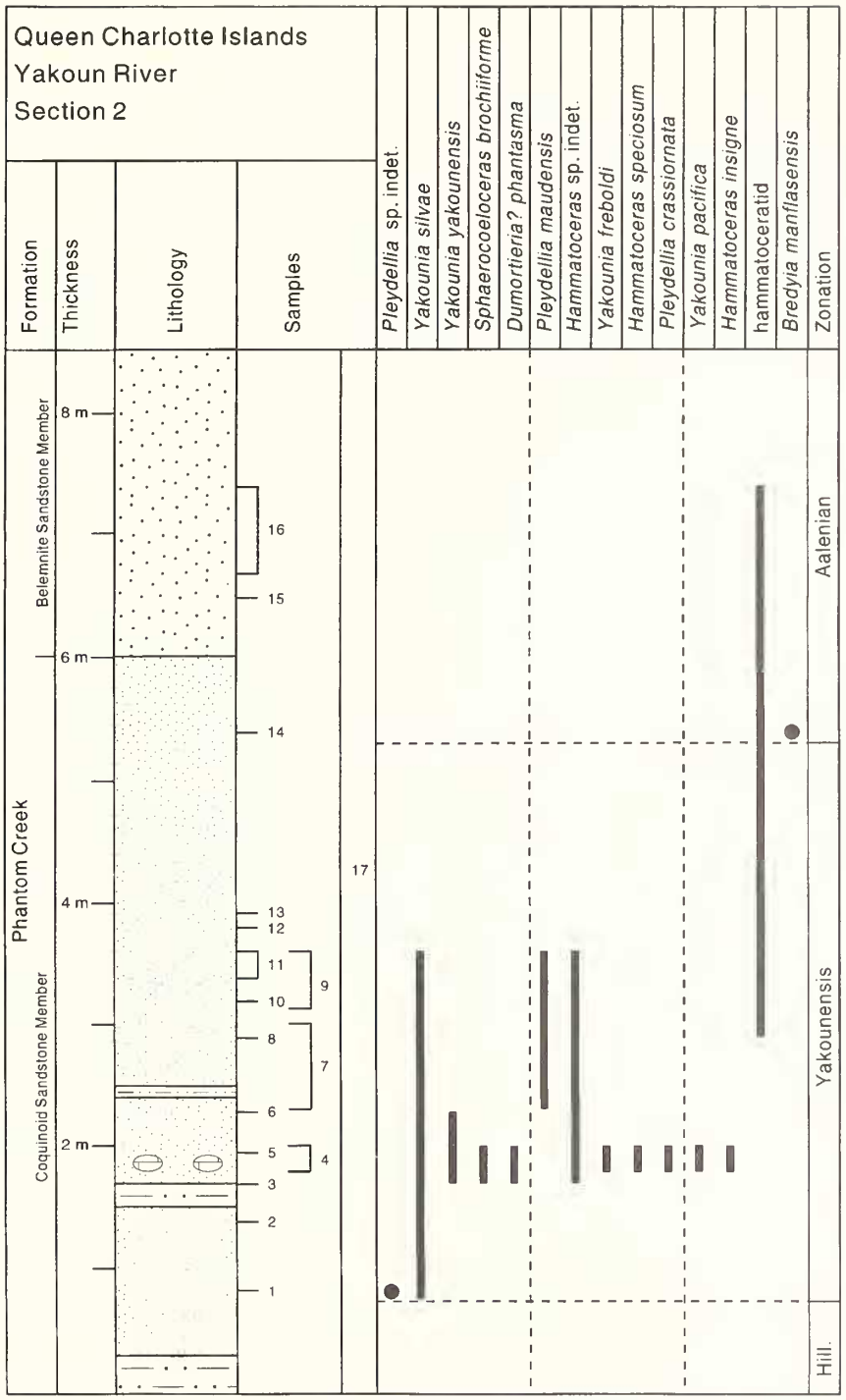
Late Toarcian ammonites including *Pleydellia maudensis*, *Yakounia silvae*, *Polyplectus*, and *Dumortieria*? *phantasma* (Collection 38) have been found in the Manson River area on the Quesnel Terrane (Text-fig. 2).

South-western British Columbia

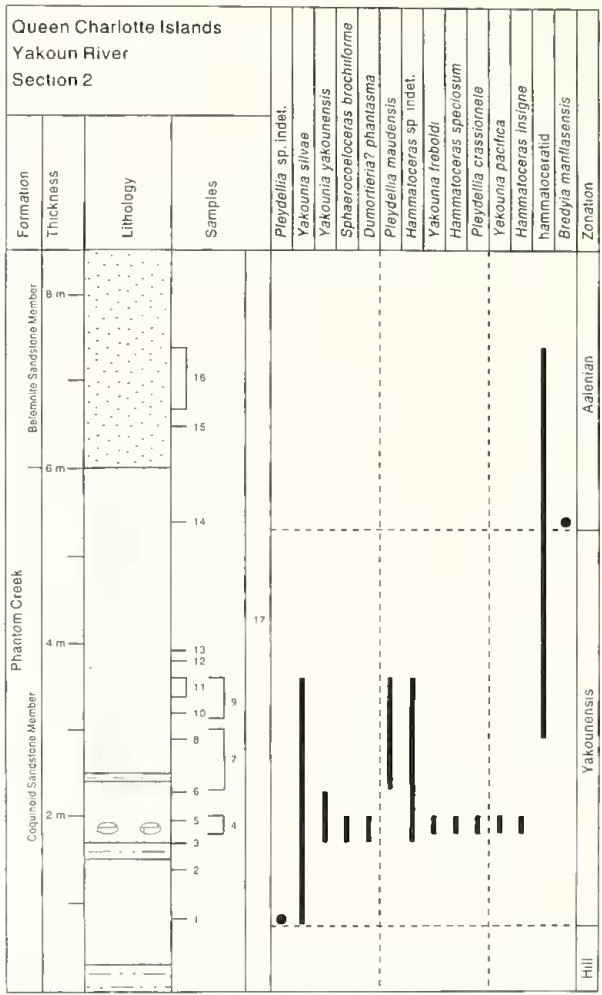
In the Taseko Lakes area (Text-fig. 2), the Lower to Middle Jurassic (Upper Hettangian to Lower Bajocian) Last Creek Formation rests unconformably on the Tyaughton Group (Umhoefer 1989). The upper part of the poorly exposed Last Creek Formation (Upper Sinemurian to Lower Bajocian) is composed of black, calcareous shales, minor sandstones, and thin ash beds. Toarcian shales of the Taseko Lakes area contain *Dumortieria*? sp. and *Hammatoceras* sp. of the Yakounensis Zone (Collections 39–41).

On the west side of Harrison Lake in south-western British Columbia (Text-fig. 2), the Jurassic Harrison Lake Formation rests unconformably on Triassic rocks (Arthur *et al.* 1993). The lowest two of four members (the Celia Cove and Francis Lake members) have yielded rare ammonites of probable Toarcian age with the highest assemblage containing species of *Dumortieria* indicating the Yakounensis Zone (Collections 42–43).

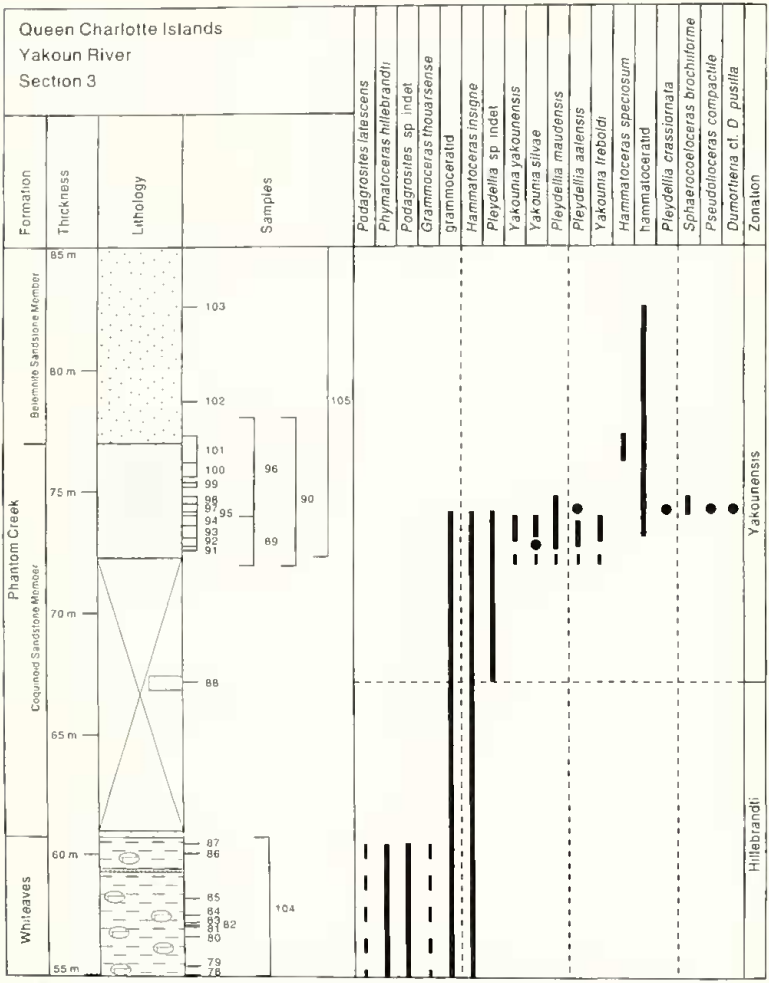
O'Brien (1987) subdivided the Ladner Group in the Boston Bar area into the Lower Jurassic Boston Bar Formation, a sequence of argillite, siltstone, greywacke and conglomerate, and the Middle Jurassic Dewdney Creek Formation, a sequence of volcanic breccia, lava and argillaceous sediments. This sequence is similar to that found to the south in Manning Park (Text-fig. 2). Toarcian ammonites collected from the Ladner Group of Manning Park were assigned to *Phlyseogrammoceras* aff. *P. dispansiforme* (Wunstorf, 1907) by Frebold (Frebold *et al.* 1969) but are comparable with *Yakounia silvae* from the Yakounensis Zone (Collection 44).



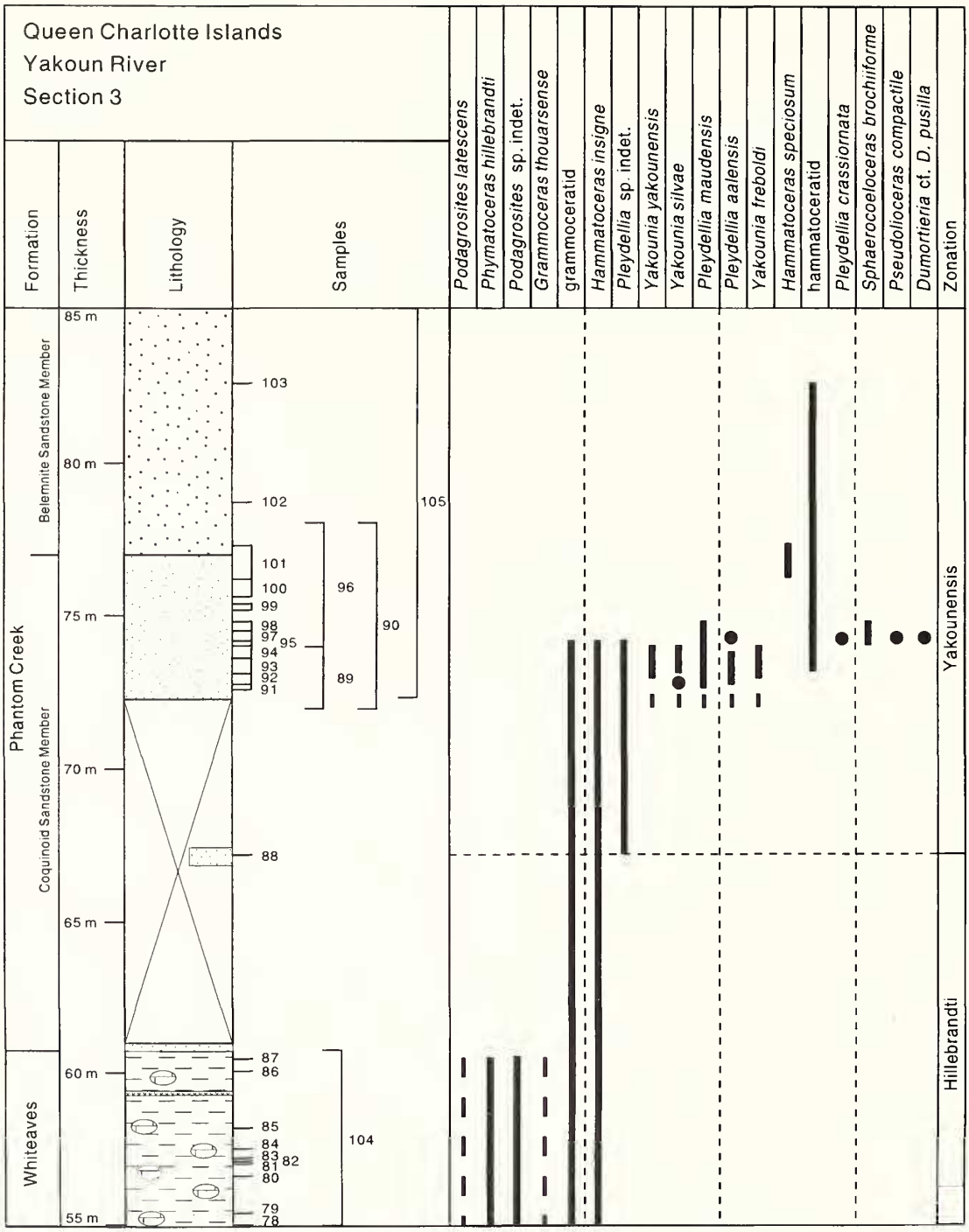
TEXT-FIG. 8. Biostratigraphy of Section 2 (Latitude 53° 25′ 05″ N, Longitude 132° 15′ 30″ W) along the Yakoun River, Queen Charlotte Islands.



TEXT-FIG. 8 Biostratigraphy of Section 2 (Latitude 53° 25′ 05″ N, Longitude 132° 15′ 30″ W) along the Yakoun River, Queen Charlotte Islands.



TEXT-FIG. 9 Biostratigraphy of Section 3 (Latitude 53° 25′ 00″ N, Longitude 132° 16′ 05″ W) along the Yakoun River, Queen Charlotte Islands.



TEXT-FIG. 9. Biostratigraphy of Section 3 (Latitude 53° 25′ 00″ N, Longitude 132° 16′ 05″ W) along the Yakoun River, Queen Charlotte Islands.

Southern Canadian Rocky Mountains

The Jurassic Fernie Formation, deposited on the North American craton, crops out from south-western Alberta to the Peace River area of north-eastern British Columbia. It includes the Toarcian Poker Chip Shale, a laterally extensive black shale, 10–38 m thick, that appears to be overlain conformably by sandstones and siltstones of the Lower Bajocian Rock Creek Member; no Aalenian ammonites have been found (Hall 1984, 1987).

In the southern outcrop area (Text-fig. 2; Collection 45), a Late Toarcian fauna of *Pleydellia mandensis* (= ?Grammoceratinae gen. et sp. indet. of Hall (1987)), *Yakounia silvae* (= ?Grammoceratinae gen. et sp. indet. of Hall (1987)), *Y. yakounensis* (= ?Grammoceratinae gen. et sp. indet. of Hall (1987)), *Sphaerocoeloceras* sp. indet. (= ?Hammatoceratidae gen. et sp. indet. of Hall (1987)), and *Dumortieria*? *phantasma* (= ?Hildoceratinae gen. et sp. indet. of Hall (1987)) has been collected. Frebold (1976) identified several forms as Middle Toarcian but these are actually Late Toarcian in age and include *Pleydellia mandensis* (= *Hangia* sp. indet. and *Hangia* aff. *H. illustris* (Denckmann, 1887) of Frebold (1976)) and *Yakounia freboldi* (= *Hangia* aff. *H. navis* (Dumortier, 1874) of Frebold (1976)) (Collections 46–51).

BIOSTRATIGRAPHY OF THE MEASURED SECTIONS

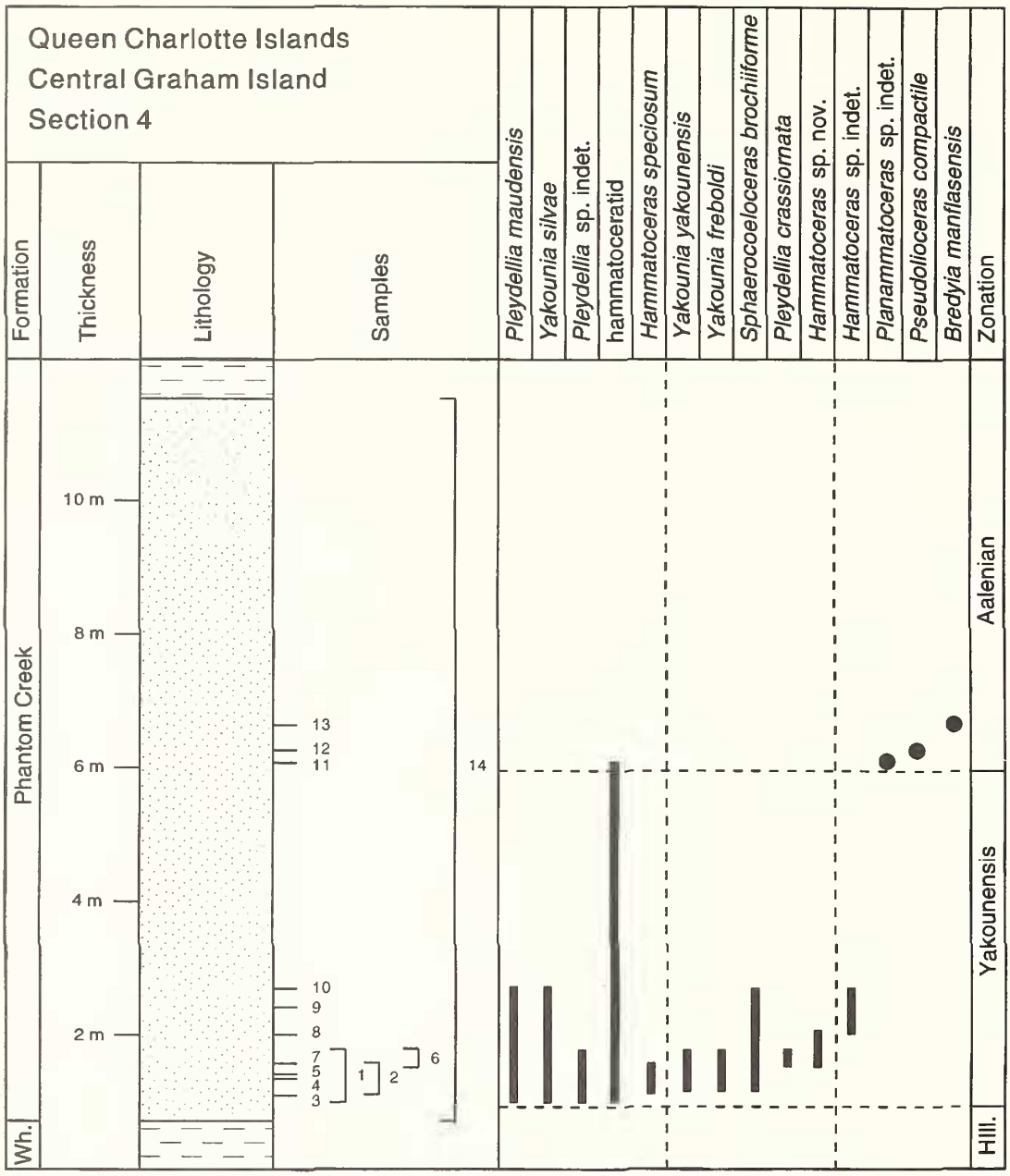
Section 1: Yakoun River. This section (Text-figs 5–7) was measured and figured originally by Cameron and Tipper (1985, Section 12) who inadvertently inverted the stratigraphy as a result of misinterpreting a poorly exposed and faulted succession. The section was re-measured during the summers of 1987–90 when lower water levels had increased exposure significantly. Siltstones of the Whiteaves Formation lie conformably beneath sandstones of the Phantom Creek Formation. The boundary between the Hillebrandti and Yakounensis zones is not well documented because of poor exposure. The boundary between the Yakounensis Zone and the Aalenian Stage is similarly not well constrained, although it appears to occur above the contact between the Coquinoid Sandstone and Belemnite Sandstone members (Jakobs 1990). The presence of *Bredyia* and *Erycitoides howelli* (White, 1889) at 17 m indicates that such taxa as *Tmetoceras* and *Troitsia* could be expected below. Radiolaria identified by E. S. Carter from concretions at 11·4 m indicate a Late Toarcian age; those at 17 m are Aalenian (Carter and Jakobs 1990).

Section 2: Yakoun River. A sequence similar to Section 1 occurs a few metres upstream (Text-figs 6, 8). The Whiteaves Formation is not exposed, but the Phantom Creek Formation is better exposed. The scarcity of ammonites makes the boundary between the Yakounensis Zone and the Aalenian Stage difficult to determine, but it appears to occur below the contact between the Coquinoid Sandstone and Belemnite Sandstone members of the Phantom Creek Formation.

Section 3: Yakoun River. This section (Text-figs 6, 9), originally measured and figured by Cameron and Tipper (1985, Section 11), was re-measured during the summers of 1987–90. The Whiteaves Formation is overlain by a sandstone unit, and a 10 m thick covered interval separates this sandstone unit from the remainder of the Phantom Creek Formation; a fault is possibly present. The top of the section is faulted.

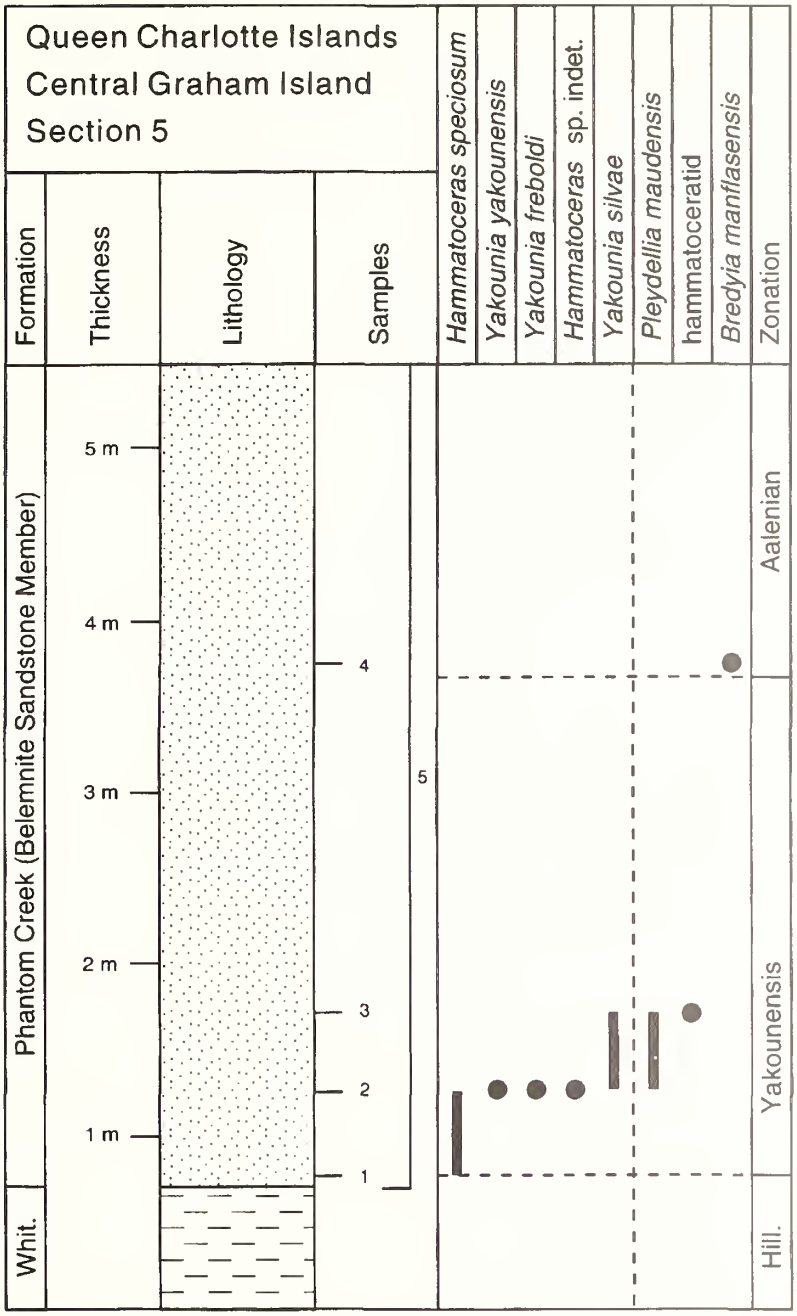
Section 4: Central Graham Island. This section (Text-figs 6, 10), measured and figured originally by Cameron and Tipper (1985, Section 14), was re-measured during the summers of 1987–90. The Whiteaves Formation appears to be overlain conformably by the Phantom Creek Formation. No fossils were collected from the Whiteaves Formation in this section, but another section nearby yielded *Phymatoceras hillebrandti* just below the contact. The boundary between the Yakounensis Zone and the Aalenian Stage is not well constrained because of poor recovery of fossils.

Sections 5–6: Central Graham Island. These two sections (Text-figs 6, 11–12) were measured at Road 59 in Central Graham Island. Section 5 had been measured and figured previously by



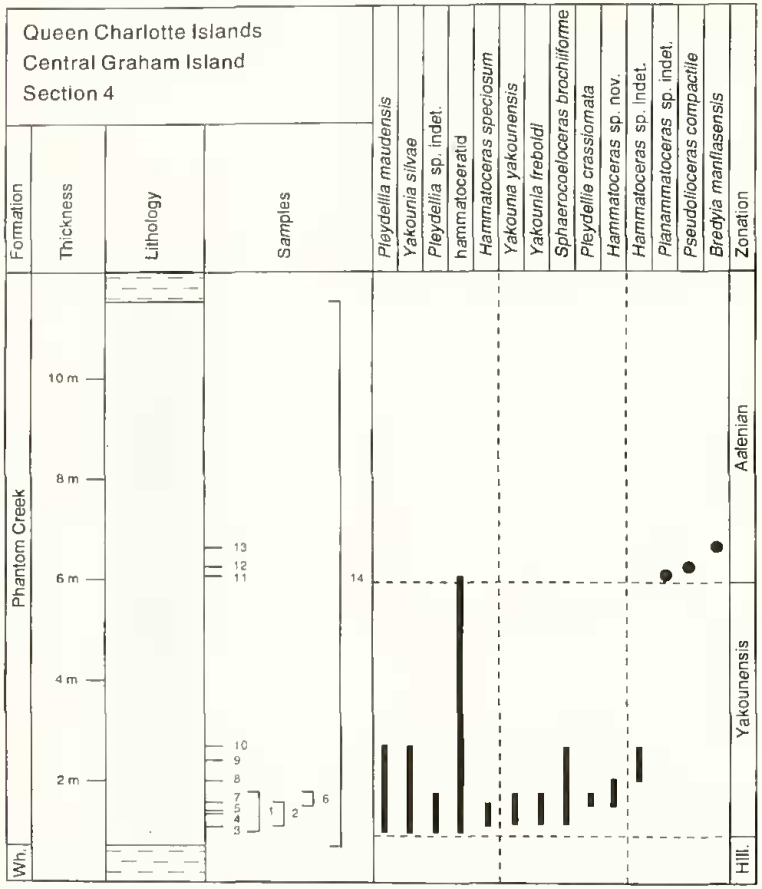
TEXT-FIG. 10. Biostratigraphy of Section 4 (Latitude 53° 23′ 35″ N, Longitude 132° 15′ 30″ W) in central Graham Island, Queen Charlotte Islands. Wh., Whiteaves; Hill., Hillebrandti.

Cameron and Tipper (1985, Section 13). The base of both sections is covered. The top of Section 5 is truncated by a fault whereas Section 6 is overlain unconformably by the Yakoun Group. The erosional hiatus between the two members of the Phantom Creek Formation has cut out the Coquinoid Sandstone Member in both sections. A single *Tmetoceras scissum* was collected from a faulted section of the Belemnite Sandstone Member.



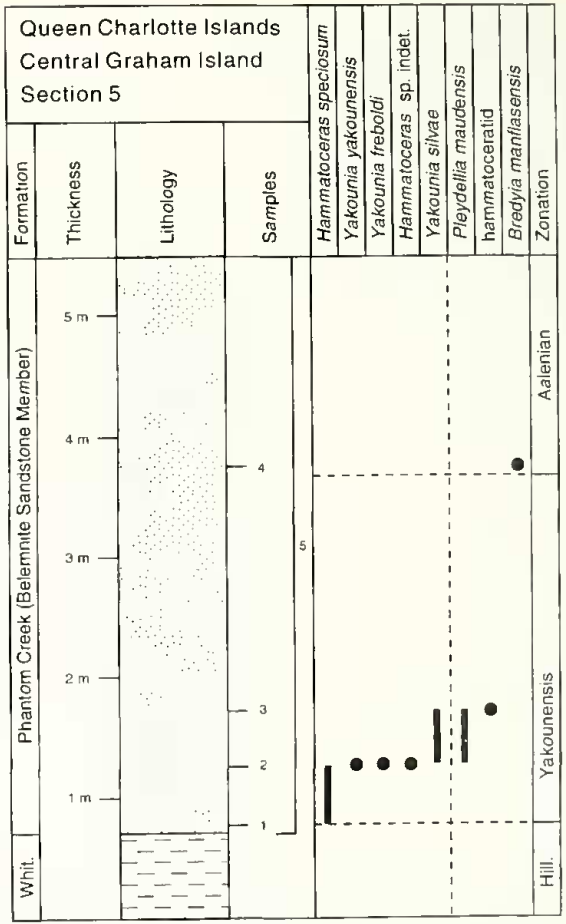
TEXT-FIG. 11. Biostratigraphy of Section 5 (Latitude 53° 23′ 00″ N, Longitude 132° 15′ 30″ W) in central Graham Island, Queen Charlotte Islands. Whit., Whiteaves; Hill., Hillebrandti.

Sections 7–8: Izee Area, Oregon. South-west of the abandoned town of Izee in east-central Oregon (Text-fig. 2), the basal Warm Springs Member of the Snowshoe Formation has yielded Late Toarcian ammonites (Dickinson and Vigrass 1964; Imlay 1968; Smith 1980). Representatives of this poorly preserved fauna were first described by Imlay (1968) but the stratigraphy at that time



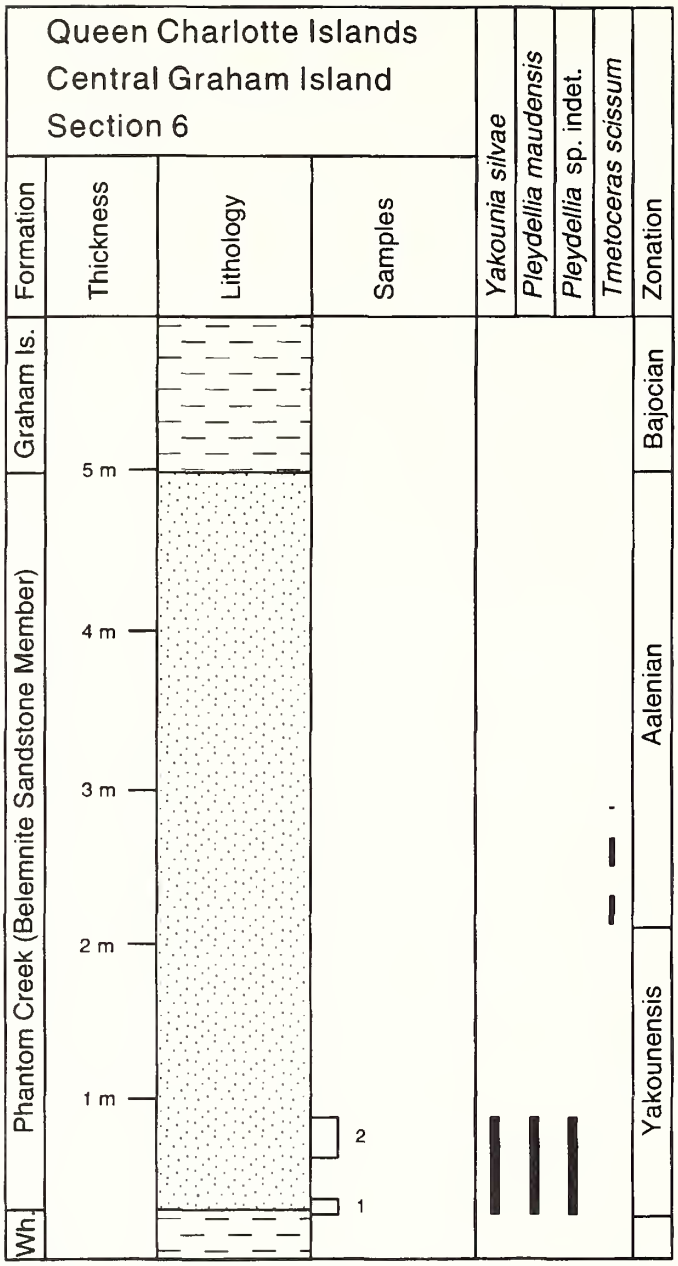
TEXT-FIG. 10. Biostratigraphy of Section 4 (Latitude 53° 23' 35" N, Longitude 132° 15' 30" W) in central Graham Island, Queen Charlotte Islands. Wh., Whiteaves; Hill., Hillebrandt.

Cameron and Tipper (1985, Section 13). The base of both sections is covered. The top of Section 5 is truncated by a fault whereas Section 6 is overlain unconformably by the Yakoun Group. The erosional hiatus between the two members of the Phantom Creek Formation has cut out the Coquimoid Sandstone Member in both sections. A single *Emetoceras scissum* was collected from a faulted section of the Belemnite Sandstone Member.



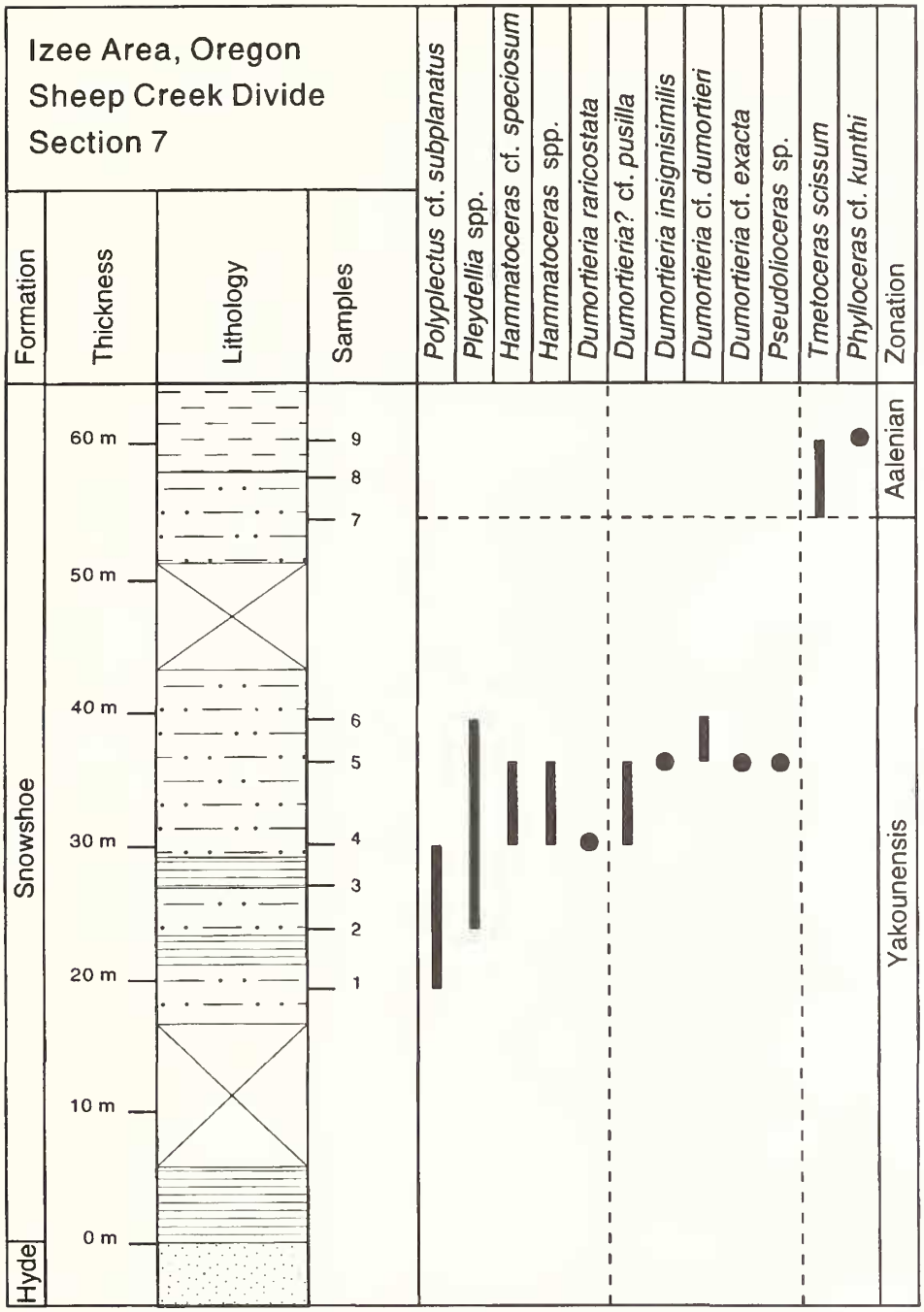
TEXT-FIG. 11. Biostratigraphy of Section 5 (Latitude 53° 23' 00" N, Longitude 132° 15' 30" W) in central Graham Island, Queen Charlotte Islands. Whit., Whiteaves; Hill., Hillebrandt.

Sections 7–8 Izee Area, Oregon. South-west of the abandoned town of Izee in east-central Oregon (Text-fig. 2), the basal Warm Springs Member of the Snowshoe Formation has yielded Late Toarcian ammonites (Dickinson and Vigrass 1964; Imlay 1968; Smith 1980). Representatives of this poorly preserved fauna were first described by Imlay (1968) but the stratigraphy at that time



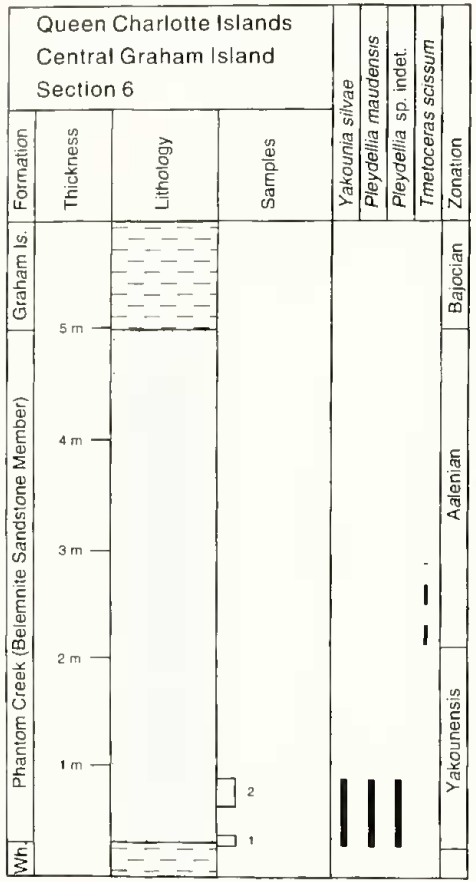
TEXT-FIG. 12. Biostratigraphy of Section 6 (Latitude 53° 23′ 00″ N, Longitude 132° 15′ 30″ W) in central Graham Island, Queen Charlotte Islands.

was poorly understood. Stratigraphical sections have now been measured at Sheep Creek Divide (Section 7; Text-fig. 13) and Flat Creek (Section 8; Text-fig. 14) where the recessive siltstones and mudstones of the Warm Springs Member rest with a gradational contact on the resistant, volcaniclastic sandstones of the Hyde Formation. Some of the original identifications of the basal Snowshoe Formation ammonites (Imlay 1968) must now be revised in the light of richer collections



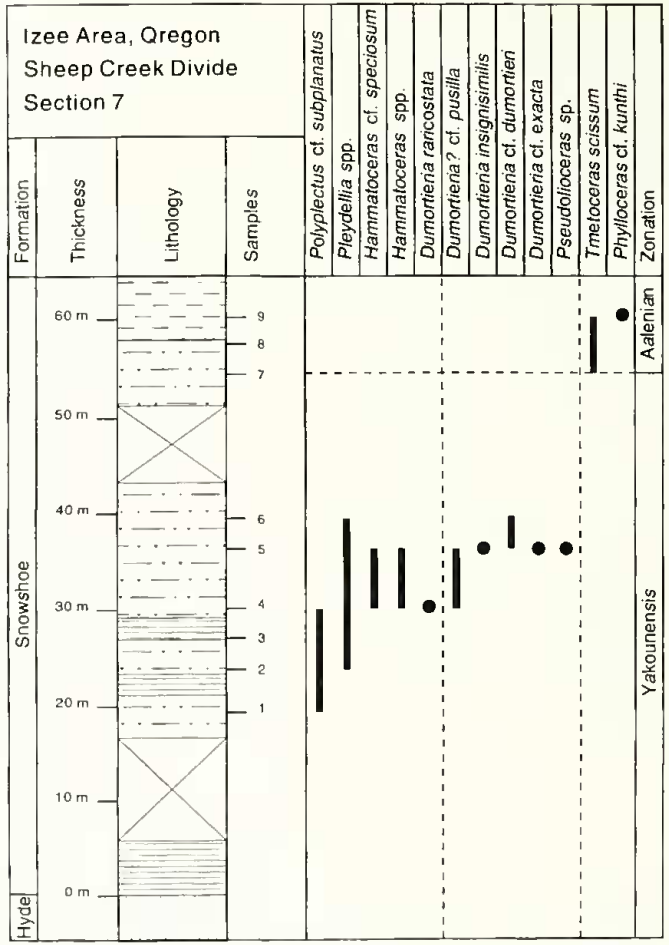
TEXT-FIG. 13. Biostratigraphy of Section 7 (Latitude 44° 03′ 17″ N, Longitude 119° 25′ 54″ W) at Sheep Creek Divide, Izee area, Oregon.

and a better understanding of the biostratigraphy. Several species of *Dumortieria* occur together with *Hammatoceras speciosum*, *Hammatoceras* spp. (= *Haugia* spp. of Imlay (1968)), *Pleydellia* spp. (= *Grammoceras* spp. of Imlay (1968)), and *Polyplectus* sp. This association is stratigraphically



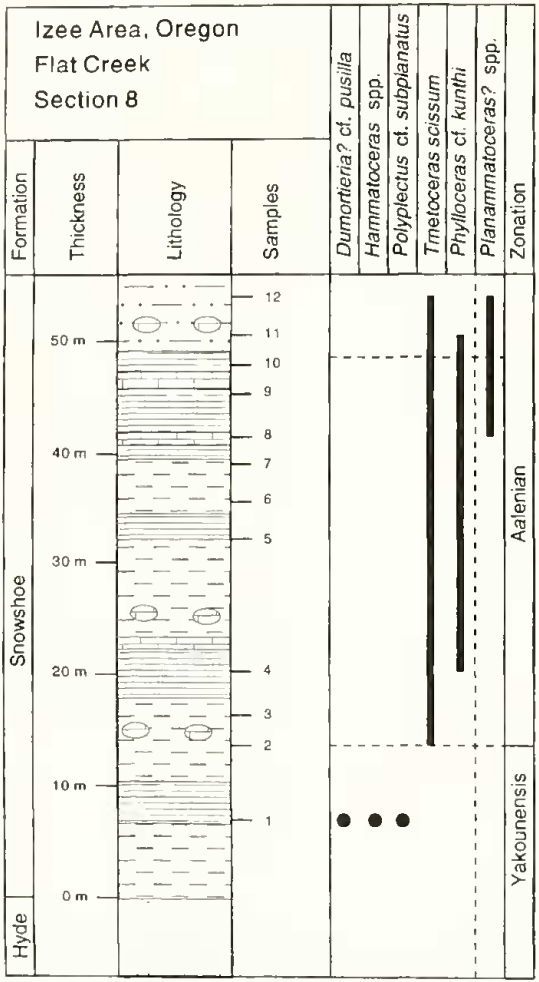
TEXT-FIG. 12 Biostratigraphy of Section 6 (Latitude 53° 23′ 00″ N, Longitude 132° 15′ 30″ W) in central Graham Island, Queen Charlotte Islands

was poorly understood. Stratigraphical sections have now been measured at Sheep Creek Divide (Section 7; Text-fig. 13) and Flat Creek (Section 8; Text-fig. 14) where the recessive siltstones and mudstones of the Warm Springs Member rest with a gradational contact on the resistant, volcaniclastic sandstones of the Hyde Formation. Some of the original identifications of the basal Snowshoe Formation ammonites (Imlay 1968) must now be revised in the light of richer collections

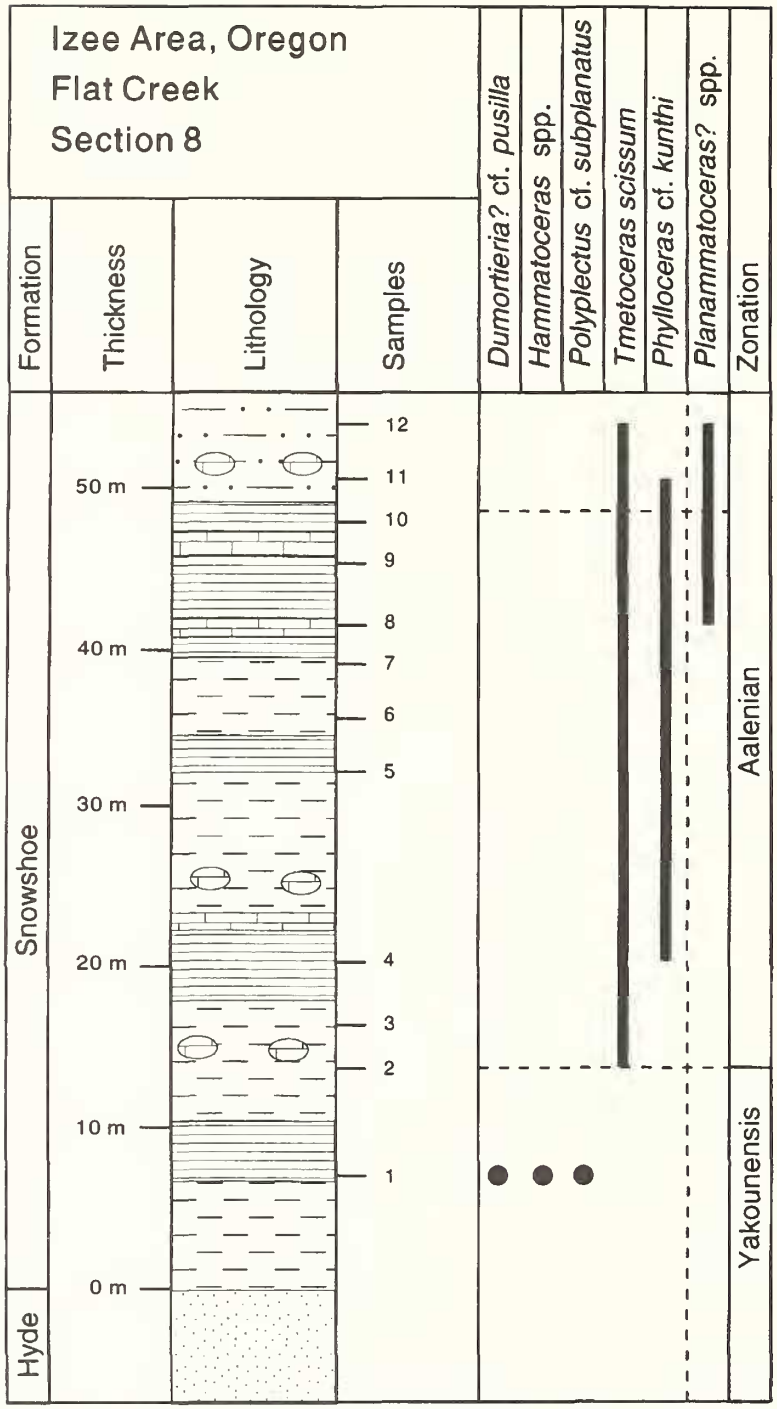


TEXT-FIG. 13 Biostratigraphy of Section 7 (Latitude 44° 03′ 17″ N, Longitude 119° 25′ 54″ W) at Sheep Creek Divide, Izee area, Oregon.

and a better understanding of the biostratigraphy. Several species of *Dumortieria* occur together with *Hammatoceras speciosum*, *Hammatoceras* spp. (= *Hungia* spp. of Imlay (1968)), *Pleydellia* spp. (= *Grammoceras* spp. of Imlay (1968)), and *Polyplectus* sp. This association is stratigraphically



TEXT-FIG. 14 Biostratigraphy of Section 8 (Latitude 44° 00′ 58″ N, Longitude 119° 28′ 23″ W) at Flat Creek, Izee area, Oregon



TEXT-FIG. 14. Biostratigraphy of Section 8 (Latitude 44° 00′ 58″ N, Longitude 119° 28′ 23″ W) at Flat Creek, Izee area, Oregon.

beneath the first occurrence of the Aalenian ammonite *Tmetoceras scissum* (see Imlay 1973) and is assigned to the Yakounensis Zone. Although the Yakounensis Zone correlates in part with the Levesquei Zone of north-west Europe, the ammonite assemblage, and particularly the common occurrence of *Polyplectus* sp., is more typical of Mediterranean successions (Donovan 1958; Géczy 1967; Goy and Martinez 1990).

Detailed locality data for Sections 1 to 8 and Collections 1 to 52 have been deposited with the British Library, Boston Spa, Yorkshire, U.K., as Supplementary Publication No. SUP 14044. The information includes geographical and stratigraphical position, locality numbers, the lithostratigraphical unit sampled, and the fauna present.

SYSTEMATIC PALAEONTOLOGY

Specimens described and illustrated in this paper are housed at the Geological Survey of Canada in Ottawa (GSC) and the University of British Columbia in Vancouver, Canada (UBC).

Abbreviations are as follows (after Smith 1986): CHW, constrictions per half whorl, counted on adoral half whorl; D, shell diameter at which measurements were made; PRHW, primary ribs per half whorl, counted on the adoral half whorl; U = (UD/D) × 100; UD, umbilical diameter; WH, whorl height; WW, whorl width; WWWH = (WW/WH) × 100. Measurements are in millimetres.

Order AMMONOIDEA von Zittel, 1884
Suborder PHYLLOCERATINA Arkell, 1950
Superfamily PHYLLOCERATACEAE von Zittel, 1884
Family PHYLLOCERATIDAE von Zittel, 1884
Subfamily CALLIPHYLLOCERTINAE Spath, 1927

Genus HOLCOPHYLLOCERAS Spath, 1927
[= *Salfeldiella* Spath, 1927; *Telegdiceras* Kovács, 1939]

Type species. Phylloceras mediterraneum Neumayr, 1871.

Diagnosis. Involute shell with high oval whorl section and plain venter; periodic, acutely sigmoidal or angular constrictions present at all stages of ontogeny; outer half of whorl appears to be ribbed; septal sutures with diphyllic saddles except for first lateral saddle which becomes triphyllic in later forms.

Distribution. Holcophylloceras is found world-wide from the Lower Jurassic (Toarcian) to the Cretaceous.

Holcophylloceras calypso (d'Orbigny, 1841)

Plate 5, figures 7–8

*1841 *Ammonites calypso* d'Orbigny, pl. 110, figs 1–3.
1976 *Holcophylloceras calypso* (d'Orbigny); Schlegelmilch, p. 26, pl. 1, fig. 6.

Material. Three specimens collected from calcareous concretions within sandstones of the Phantom Creek Formation, Queen Charlotte Islands (Section 2, loc. 17, talus).

Measurements.	D	UD	U	WH	WW	WWWH	CHW
GSC 107260	27·3	2·8	10·3	14·8	10·5	0·71	4
GSC 107260	—	—	—	8·9	6·4	0·72	—
GSC 107304	—	—	—	6·9	5·7	0·83	—
GSC 107305	17·1	2·3	13·5	8·1	6·9	0·85	3

Description. Involute shell with a high oval whorl section and gently sloping umbilical wall. Ornament consists of about eight sinuous constrictions per whorl. Sutures are diphyllic.

Distribution. Holcophylloceras calpyso is found world-wide in the Toarcian.

Suborder AMMONITINA Hyatt, 1889
Superfamily HILDOCERATACEAE Hyatt, 1867
Family HILDOCERATIDAE Hyatt, 1867
Subfamily GRAMMOCERATINAE Buckman, 1904

Genus PLEYDELLIA Buckman, 1899
[= *Cotteswoldia* Buckman, 1902 (= *Gotteswaldia* Théobald, 1950); *Canavaria* Buckman, 1902 (*non* Gemmellaro, 1886) (= *Canavarina Buckman*, 1904); *Walkeria* Buckman, 1902 (= *Walkericeras* Buckman, 1913)]

Type species. Pleydellia comata Buckman, 1899.

Diagnosis. Involute to evolute shell with tall, compressed whorls; whorl section lanceolate to triangular; umbilical shoulder abrupt to moderately rounded; venter carinate with weak ventro-lateral shoulders; ribbing sinuous, prorsiradiate on upper flank, and terminating at ventro-lateral shoulder. Ribs may bifurcate at or near umbilical shoulder, and may fade on inner or outer half of flanks.

Distribution. Pleydellia is common in the uppermost Toarcian of Europe, South America and North America.

Pleydellia maudensis sp. nov.

Plate 1, figures 1–2; Plate 2, figures 1–2, 11–12; Text-figure 15A

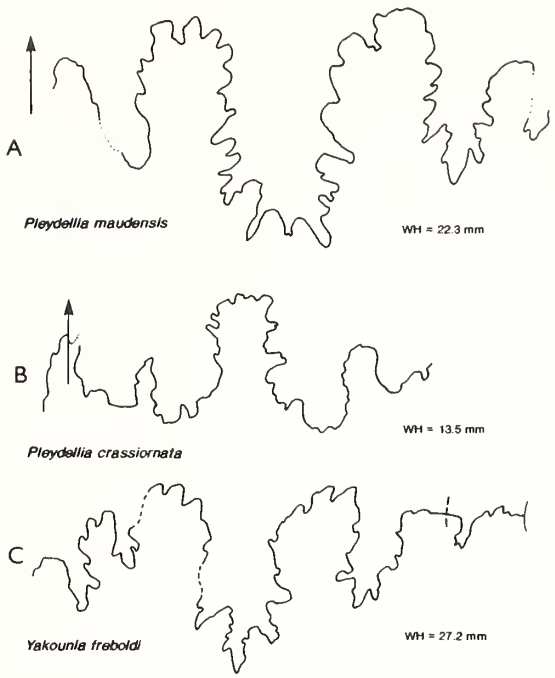
	1981	*Haugia* cf. *compressa* Buckman; Imlay, p. 43, pl. 12, figs 3, 7, 9.
	1981	*Haugia* cf. *grandis* Buckman; Imlay, p. 42, pl. 12, figs 4, 10, 15.
	1981	*Brodieia* cf. *B. tenuicostata* var. *nodosa* Jaworski; Imlay, p. 42, pl. 12, fig. 8.
v	1987	?Grammoceratinae gen. et sp. indet., Hall, p. 1702, pl. 5, figs A–J, P, W.
	1991	*Phlyseogrammoceras* (?) sp., Tipper *et al.*, pl. 7, fig. 3.
	1992	*Haugia* cf. *compressa* Buckman; Hillebrandt and Smith, pl. 4, fig. 7.
	1992	?*Haugia* sp. indet., Hillebrandt and Smith, pl. 7, fig. 5.

Derivation of name. After Maude Island in Skidegate Inlet, site of some of the first discoveries of Jurassic fossils in the Queen Charlotte Islands.

Material. About 150 specimens in sandstones and calcareous concretions of the Phantom Creek Formation, Queen Charlotte Islands (Section 1, locs 3, 5, 17; Section 2, locs 3, 7, 9, 12, 17; Section 3, locs 89–92, 94–95, 97–98; Section 4, locs 1–3, 5–6, 8–10, 14; Section 5, locs 2–3, 5; Section 6, locs 1–2). Other specimens from the Upper Toarcian of the Talkeetna Mountains (Text-fig. 2, Collection 2), Puale Bay (Collection 10), the Iskut area (Collections 18–19), the Spatsizi area (Collections 21–22), the Hazelton area (Collection 36), the Manson River area (Collection 38), and the southern Canadian Rocky Mountains (Collections 45–46, 48).

Holotype. GSC 99523 (Pl. 2, figs 11–12) from the lower part of the Phantom Creek Formation (Yakounensis Zone), Yakoun River, Queen Charlotte Islands.

Paratypes. GSC 99519 (Pl. 2, figs 1–2), GSC 99524 (Pl. 1, figs 1–2), GSC 99509, GSC 107267–107277.



TEXT-FIG. 15. Septal suture lines of *Pleydellia maudensis*, *Pleydellia crassiornata* and *Yakounia freboldi* from the Queen Charlotte Islands. A, GSC 99519; Section 4, loc. 14; B, GSC 107347; Section 3, loc. 95; C GSC 107286, Section 4, loc. 4. WH, whorl height.

Measurements.	D	UD	U	WH	WW	WWHH	PRHW
GSC 99523	112·2	40·0	35·7	42·1	23·0	0·55	14
GSC 99523	93·7	31·0	33·1	35·0	24·9	0·71	—
GSC 99523	81·8	24·7	30·2	32·0	19·1	0·60	*c.* 16
GSC 99519	98·5	28·9	29·3	40·0	21·4	0·54	*c.* 15
GSC 99519	79·4	22·0	27·7	34·1	19·7	0·58	14
GSC 99519	75·0	20·1	26·8	31·8	—	—	13
GSC 99524	153·0	57·9	37·8	—	—	—	—
GSC 99524	124·0	38·0	30·6	—	—	—	—
GSC 107267	—	—	—	8·3	6·2	0·75	—
GSC 107268	58·5	22·1	37·8	21·6	14·8	0·69	16
GSC 107268	46·1	17·0	36·9	17·0	10·9	0·64	11
GSC 107269	42·9	11·1	25·9	18·4	—	—	—
GSC 107269	37·5	10·0	26·7	—	—	—	—
GSC 107269	34·0	9·0	26·5	15·0	—	—	12
GSC 107270	98·9	32·7	33·1	—	—	—	17
GSC 107271	71·8	22·0	30·6	29·8	18·1	0·61	11
GSC 107271	56·5	17·1	30·3	24·0	14·5	0·60	12
GSC 107272	47·5	12·5	26·3	20·7	10·7	0·52	13
GSC 107273	79·3	25·4	32·0	32·1	—	—	15
GSC 107273	63·7	21·1	33·1	25·1	—	—	15
GSC 107273	58·5	20·0	34·2	22·6	—	—	*c.* 13
GSC 107274	87·4	29·0	33·2	36·0	—	—	15
GSC 107275	64·7	20·3	31·4	25·2	19·0	0·75	11
GSC 107275	55·2	16·4	29·7	—	—	—	10
GSC 107276	91·1	28·1	30·8	36·2	21·0	0·58	13
GSC 107276	67·3	19·0	28·2	28·4	15·8	0·56	12
GSC 107277	82·6	21·7	26·3	36·1	—	—	13

Diagnosis. Moderately evolute shell; ogival whorl section and flat flanks; umbilical wall gently sloping, becoming undercut on outer whorls; umbilical shoulder gently rounded becoming sharp on outer whorls; venter carinate-sulcate; lateral sulci fade during ontogeny; ribbing sinuous. On inner whorls, primary ribs bifurcate at about one-third flank height. On outer whorls, ribs arise singly and in pairs from small tubercles at umbilical shoulder. Ribs weaken on upper flank. Some ribs bifurcate on upper flank or intercalatory ribs may appear. Ribs terminate at ventro-lateral shoulder.

Description. The holotype, GSC 99523, is a moderately well preserved specimen, septate up to 77·4 mm shell diameter with approximately 190° of body chamber, ending in an incomplete aperture at 111·4 mm shell diameter. One side is slightly distorted. The shell is moderately evolute with an ogival whorl section, flat flanks, and a carinate-sulcate venter. The umbilical wall is gently sloping on the inner whorls becoming steeper with age until, at approximately 82 mm shell diameter, it becomes slightly undercut. The umbilical shoulder is gently rounded on the inner whorls, becoming angular as the umbilical wall steepens. The venter possesses shallow lateral sulci which fade on the outer whorls. On the inner whorls, the primary ribs are slightly prorsiradiate. On the outer whorls, the primary ribs arise from small tubercles at the umbilical shoulder and have a more pronounced prorsiradiate trend. The primary ribs are stronger than the secondary ribs which appear at approximately mid-flank. The paratype, GSC 99519, is a moderately well preserved specimen, septate to 77·1 mm shell diameter with approximately 130° of body chamber, ending in an incomplete aperture at 100·4 mm shell diameter. The phragmocone is damaged on one side and is partially obscured by encrusting bivalves. The body chamber is partially crushed. This specimen illustrates the ribbing on the outer whorls of the phragmocone. From the umbilical tubercles, a primary rib proceeds across the flank and bifurcates at approximately one-quarter to one-third the flank height. At approximately two-thirds to three-quarters the flank height, the ribs may bifurcate again or weak intercalatory ribs may arise. The ribbing fades on the body chamber. The paratype, GSC 99524, is a larger specimen, albeit less well preserved. It is septate to 121·7 mm shell diameter with approximately 190° of body chamber ending in an incomplete aperture at 165 mm shell diameter. One side is poorly preserved and partially obscured by encrusting bivalves. The body chamber is fragmented and parts of the venter have been eroded or broken away. The phragmocone lacks fine detail because of the medium-grained sandstone that forms the matrix. This specimen, whilst having faint ribbing on the outer whorls, maintains the tubercles at the umbilical shoulder and these do not fade but remain prominent. Of the other paratypes, one specimen (GSC 107268) differs slightly in that it is slightly more evolute and has more pronounced umbilical tubercles from which three ribs commonly arise. Two other specimens (GSC 99509 and GSC 107267) are fragments of inner whorls. Both show strong primary ribs which bifurcate at mid-flank. The venter is more strongly carinate-sulcate than on the larger specimens.

Remarks. This form is similar to several Late Toarcian genera including *Pseudolillia*, *Gruneria*, *Phlyseogrammoceras*, as well as *Pleydellia*. The whorl shape and rib pattern on the outer whorls are similar to species of *Pseudolillia* figured by Elmi and Rulleau (1987) but the inner whorls are different. Ribbing on the inner whorls of *Pseudolillia* is much denser and finer, and the ribs tend to bundle or remain single rather than bifurcating as markedly as in *Pleydellia maudensis*. In addition, *Pseudolillia* lacks the small umbilical swellings characteristic of the North American species. *Gruneria* has a similar ribbing pattern in which the primary ribs on the inner whorls bifurcate on the lower to mid-flank; however, the whorl shape is more rounded and ellipsoidal, the ribs are finer and denser, and the outer whorls lack the small umbilical swellings that characterize *Pl. maudensis*. *Phlyseogrammoceras* has a similar ribbing pattern, and a steep to undercut umbilical wall on the outer whorls, but the whorl section is more compressed and the venter is sharper, lacking the ventral sulci of *Pl. maudensis*. Hillebrandt (1987) figured several specimens which he assigned to *Phlyseogrammoceras* (?) *tenuicostatum*, a form similar to the North American species but with a more involute shell. Hall (1987) described specimens from the Fernie Formation (?Grammoceratinae gen. et sp. indet.) which he compared with species of *Pleydellia* such as *Pl. fluitans* (Dumortier, 1874)

EXPLANATION OF PLATE 1

Figs 1–2. *Pleydellia maudensis* sp. nov.; GSC 99524, paratype; Yakounensis Zone, lower part of the Phantom Creek Formation; Queen Charlotte Islands, GSC Loc. No. C-87111, Section 3, loc. 89; × 1.

JAKOBS and SMITH, *Pleydellia maudensis*

and *Pl. lotharingica*. *Pl. fluitans* has coarse, distant, rectiradiate ribs and a bisulcate venter, whereas *Pl. lotharingica* has a narrow venter and an ogival whorl section (Knitter and Ohmert 1983, pl. 3, figs 12–14). Hillebrandt (1987, pl. 13, fig. 7, pl. 14, fig. 8) figured several specimens of *Pl.* cf. *lotharingica* which have a bisulcate venter on the inner whorls and a similar ribbing pattern, but lack the undercut umbilical shoulder and umbilical swellings on the outer whorls that characterize *Pl. maudensis*. The North American form has a strong carinate-sulcate inner whorl and subdued umbilical swellings that are significantly different from other *Pleydellia*, and a new species designation is warranted.

Pleydellia crassiornata sp. nov.

Plate 3, figures 1–8; Text-figure 15B

Derivation of name. The name refers to the thick ornamentation (Latin *crassus*, thick; *ornatus*, ornament).

Material. About 24 well preserved specimens in sandstones and calcareous concretions of the Phantom Creek Formation (Section 1, locs 5, 17; Section 2, locs 4, 17; Section 3, locs 90, 95; Section 4, locs 6, 14), Queen Charlotte Islands.

Holotype. GSC 99513 (Pl. 3, figs 7–8) from the lower part of the Phantom Creek Formation (middle Yakounensis Zone), Yakoun River, Queen Charlotte Islands.

Paratypes. GSC 99510 (Pl. 3, figs 1–2), GSC 99511 (Pl. 3, figs 3–4), GSC 99512 (Pl. 3, figs 5–6), GSC 107278–107279

Measurements.	D	UD	U	WH	WW	WWWH	PRHW
GSC 99513	48·7	19·4	39·8	—	—	—	—
GSC 99513	38·7	14·5	37·5	—	—	—	9
GSC 99513	—	10·8	—	9·6	7·4	0·77	9
GSC 99511	46·3	15·6	33·7	17·1	9·0	0·53	—
GSC 99511	40·0	12·4	31·0	16·1	9·5	0·59	—
GSC 99511	35·9	11·1	30·9	15·0	8·9	0·59	—
GSC 107278	—	20·3	—	18·1	12·7	0·70	13
GSC 107278	34·5	10·8	31·3	14·0	10·0	0·71	10
GSC 107278	28·3	10·0	35·3	11·5	8·8	0·77	—
GSC 107279	58·3	26·2	44·9	16·5	13·6	0·82	12
GSC 107279	53·1	21·3	40·1	17·2	11·6	0·67	11
GSC 107279	48·3	18·5	38·3	14·1	10·9	0·77	11

EXPLANATION OF PLATE 2

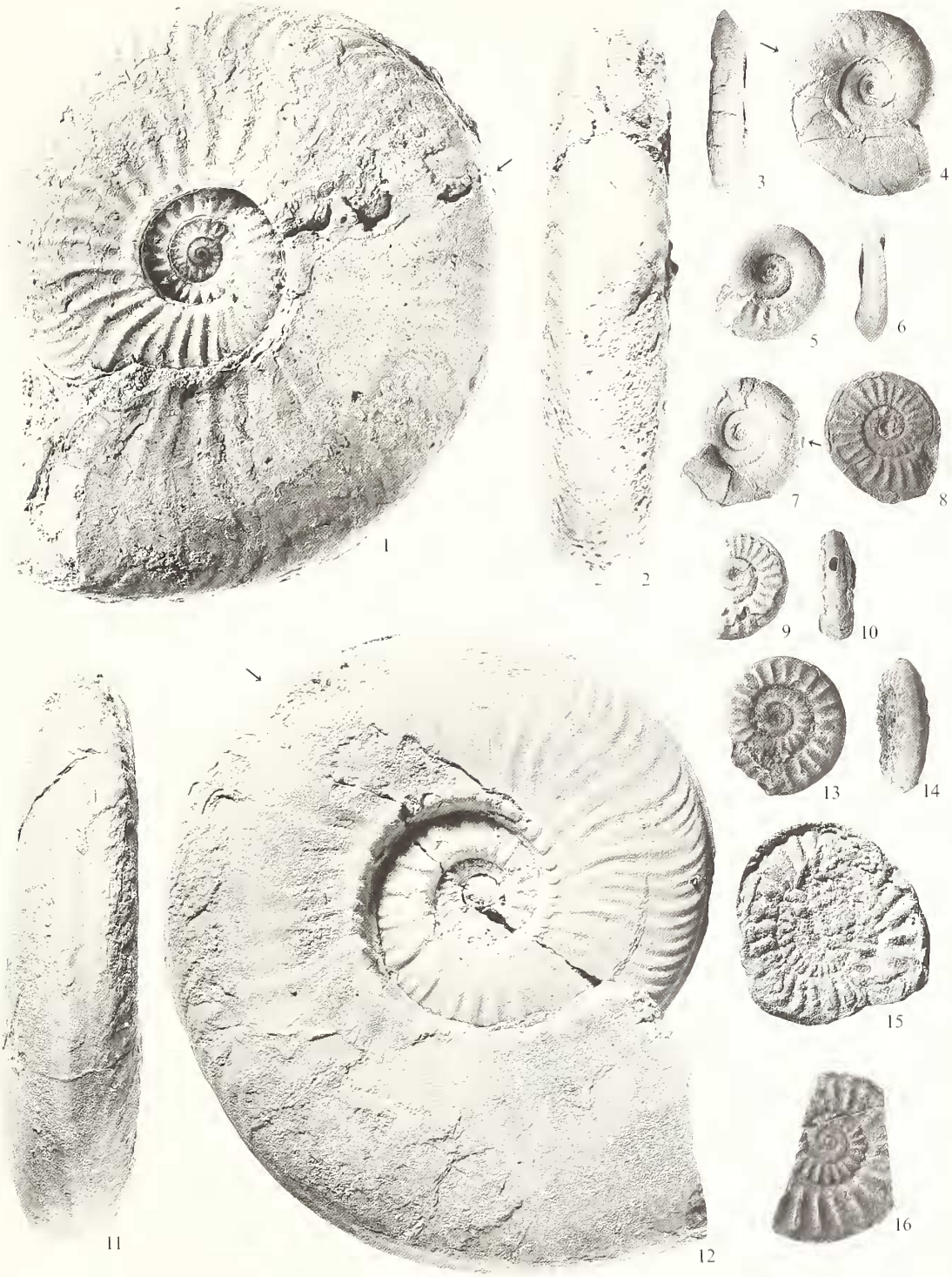
Figs 1–2, 11–12. *Pleydellia maudensis* sp. nov.; Yakounensis Zone, lower part of the Phantom Creek Formation; Queen Charlotte Islands. 1–2, GSC 99519, paratype; GSC Loc. No. C-176555, Section 4, loc. 14. 11–12, GSC 99523, holotype; GSC Loc. no. C-87118, Section 3, loc. 95.

Figs 3–7. *Dumortieria? phantasma* sp. nov.; Yakounensis Zone, lower part of the Phantom Creek Formation; Queen Charlotte Islands. 3–4, GSC 99520, holotype; GSC Loc. No. C-87220, Section 2, loc. 4. 5–6, GSC 99521, paratype; GSC Loc. No. C-93576, Section 2, loc. 4. 7, GSC 99522, paratype; GSC Loc. No. C-87220, Section 2, loc. 4.

Figs 8, 15–16. *Dumortieria*? cf. *pusilla* Jaworski; Yakounensis Zone, Warm Springs Member of the Snowshoe Formation; Izee area, eastern Oregon. 8, UBC 014; UBC Loc. No. F4-4-E, Section 7, loc. 5. 15, UBC 015; UBC Loc. No. F4-4-E, Section 7, loc. 5. 16, UBC 016; UBC Loc. No. F5-1-4, Collection 52.

Figs 9–10, 13–14. *Dumortieria pusilla* Jaworski; Arroyo Negro Argentina, Locality 22, Section 9, Horizon 6 of Jaworski (1926). 9–10, plaster cast of the paratype. 13–14, plaster cast of the holotype.

Arrows mark start of body chamber. All are ×1.



JAKOBS and SMITH, *Pleydellia* and *Dumortieria*

Diagnosis. Moderately evolute shell; ogival whorl section; umbilical wall gently sloping, becoming steeper during ontogeny; umbilical shoulder gently rounded, becoming more angular during ontogeny; flanks slightly convex; venter carinate with weak lateral sulci on inner whorls; ribbing sinuous; thick, prominent primary ribs split into two or three weaker, secondary ribs at approximately one-third to one-half flank height; secondary ribs terminate at ventro-lateral shoulder; some variation in length of primary ribs.

Description. The holotype, GSC 99513, is a moderately well preserved specimen septate to 13·1 mm umbilical diameter with approximately 180° of body chamber ending in an incomplete aperture at 49·0 mm shell diameter. The body chamber is broken and slightly crushed. The shell is moderately evolute with an ogival whorl section. The umbilical wall is gently sloping and the umbilical shoulder is rounded. The flanks are gently convex and merge into the venter with only weak ventro-lateral shoulders. The venter is carinate, bounded by narrow, smooth strips. The ornament consists of sinuous ribs. The coarse primary ribs arise high on the umbilical wall. On the inner whorls, they are short and appear bullate. The primary ribs split into two or three weaker secondary ribs at approximately one-third to one-half the flank height. The secondary ribs terminate at the ventro-lateral shoulder. The paratype, GSC 99511, is a well preserved specimen septate to 43·1 mm shell diameter with approximately 70° of body chamber ending in an incomplete aperture at 47·5 mm shell diameter. The body chamber is slightly crushed. The shell is moderately evolute with an ogival whorl section and possesses similar shell characteristics to the holotype. The ornament differs slightly by being slightly more subdued, and the primary ribs are longer on the inner whorls and not as bullate. The paratype, GSC 99512, is a moderately well preserved shell, septate to 16·6 mm umbilical diameter with approximately 110° of body chamber ending in an incomplete aperture. Most of the venter on the outer whorl of the phragmocone has been eroded away. This specimen is similar to the previous two but has slightly longer primary ribs on the inner whorls than the holotype. The paratype, GSC 99510, is a moderately well preserved shell with approximately 180° of body chamber. The shell is fragmented and distorted with portions of the phragmocone broken away. This specimen is one of the largest, with a maximum shell diameter of approximately 66 mm. It possesses a similar ribbing pattern to the two previous paratypes. The ornament does not fade on the body chamber. The paratype, GSC 107279, is a well preserved specimen septate to 25·0 mm umbilical diameter and with approximately 190° of body chamber ending in an incomplete aperture. The primary ribs on the inner whorls, while not as bullate as the holotype, are shorter than in the other paratypes. The paratype, GSC 107278, is a moderately well preserved specimen with approximately 180° of body chamber ending in an incomplete aperture. Part of the venter on the body chamber is broken away. It is a smaller specimen than the others, and the whorl section is slightly more depressed. The ornament is similar to the other paratypes.

EXPLANATION OF PLATE 3

Figs 1–8. *Pleydellia crassiornata* sp. nov.; Yakounensis Zone, lower part of the Phantom Creek Formation; Queen Charlotte Islands. 1–2, GSC 99510, paratype; GSC Loc. No. C-87118, Section 3, loc. 95. 3–4, GSC 99511, paratype; GSC Loc. No. C-87221, Section 2, loc. 17. 5–6, GSC 99512, paratype; GSC Loc. No. C-176555, Section 4, loc. 14. 7–8, GSC 99513, holotype; GSC Loc. No. C-87118, Section 3, loc. 95.

Figs 9–14. *Pleydellia aalensis* (Zieten); Yakounensis Zone, lower part of the Phantom Creek Formation; Queen Charlotte Islands. 9–10, GSC 99514; GSC Loc. No. C-87107, Section 3, loc. 95. 11–12, GSC 99515; GSC Loc. No. C-87233, Section 1, loc. 17. 13–14, GSC 99516; GSC Loc. No. C-87233, Section 1, loc. 17.

Fig. 15. *Dumortieria* cf. *exacta* Buckman; UBC 010; Yakounensis Zone, Warm Springs Member of the Snowshoe Formation; Izee area, eastern Oregon, UBC Loc. No. F4-4-E, Section 7, loc. 5.

Fig. 16. *Dumortieria* cf. *dumortieri* (Thiollière); UBC 011; Yakounensis Zone, Warm Springs Member of the Snowshoe Formation; Izee area, eastern Oregon, UBC Loc. No. F4-4-F, Section 7, loc. 6.

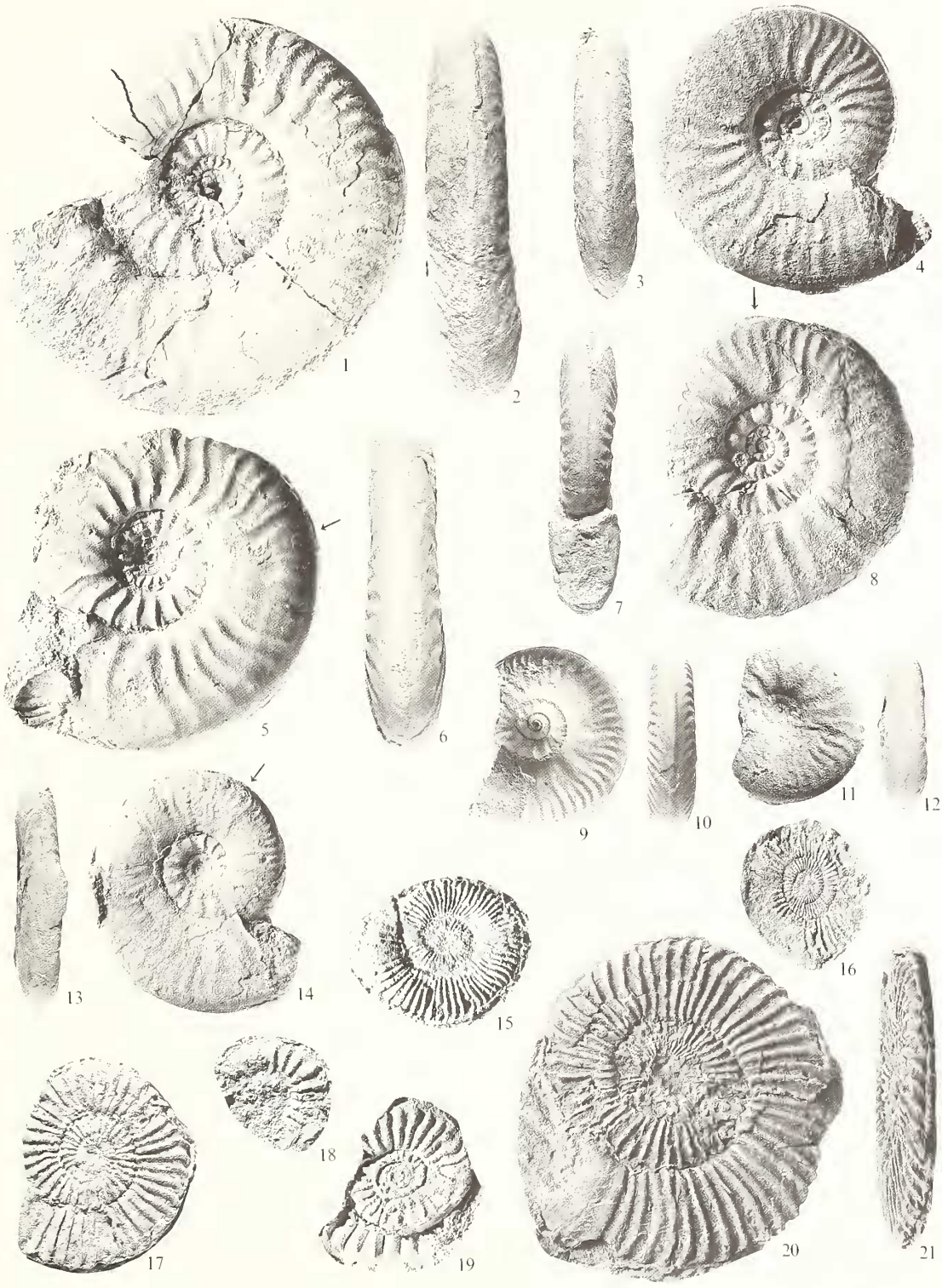
Fig. 17. *Dumortieria insignisimilis* (Brauns); UBC 012; Yakounensis Zone, Warm Springs Member of the Snowshoe Formation; Izee area, eastern Oregon, UBC Loc. No. F4-4-E, Section 7, loc. 5.

Fig. 18. *Dumortieria*? cf. *pusilla* Jaworski; GSC 99517; Yakounensis Zone, lower part of the Phantom Creek Formation; Queen Charlotte Islands, GSC Loc. No. C-157740, Section 3, loc. 97.

Fig. 19. *Dumortieria insignisimilis* (Brauns); GSC 99518; Yakounensis Zone, lower part of the Phantom Creek Formation; Queen Charlotte Islands, GSC Loc. No. C-81736, Section 5, loc. 5.

Fig. 20. *Dumortieria raricostata* Géczy; UBC 013; Yakounensis Zone, Warm Springs Member of the Snowshoe Formation; Izee area, eastern Oregon, UBC Loc. No. F4-3-D, Section 7, loc. 4.

Arrows mark start of body chamber. All are × 1.



JAKOBS and SMITH, *Pleydellia* and *Dumortieria*

Remarks. The shell shape and whorl section are similar to those of *Pleydellia aalensis* as figured by Schlegelmilch (1976, pl. 51, figs 8–9). *Pl. aalensis* encompasses a broad variety of forms and shows wide morphological variability. In general, the style of joined ribs distinguishes *Pl. aalensis* from other species of *Pleydellia* (Buckman 1890, p. 193), some of which have joined ribs but these tend to be fine and bundled, e.g. *Pl. subcompta* (Branco, 1879). The specimens of *Pl. aalensis* illustrated by Buckman (1890, pl. 32, figs 4–10) differ from *Pl. crassiornata* by lacking swollen primaries, by being slightly more involute, and by having a steeper umbilical wall. Géczy (1967) figured several forms of *Pl. aalensis*, creating several new subspecies that are similar to *Pl. crassiornata* but which lack the prominent and pervasive bifurcation and swollen primaries that characterize the North American species. *Pleydellia* from North America that have bifurcate and widely spaced ribbing show some differences in the coarseness of the primary ribs, but this may be intra-specific variation and is probably not sufficient to justify the recognition of two separate species.

Pleydellia crassiornata also shows similarity to the Leioceratinae which, according to Donovan *et al.* (1981, p. 115), evolved from *Pleydellia* during the early Aalenian. Schlegelmilch (1985) figured some species of *Leioceras* and *Staufenia* (pls 9–11) which are similar to *Pl. crassiornata*. *Leioceras* and *Staufenia* have acute venters and simple septal sutures.

Pleydellia aalensis (Zieten, 1832)

Plate 3, figures 9–14

*1832	*Ammonites aalensis* Zieten, pl. 28, fig. 3.
1890	*Grammoceras aalense* (Zieten); Buckman, p. 192, pl. 32, figs 7–8.
1976	*Pleydellia aalensis* (Zieten); Schlegelmilch, p. 94, pl. 51, figs 8–9.
1983	*Pleydellia aalensis* (Zieten); Knitter and Ohmert, pl. 3, figs 2–3.
1990	*Pleydellia aalensis* (Zieten); Goy and Martínez, pl. 4, fig. 10.

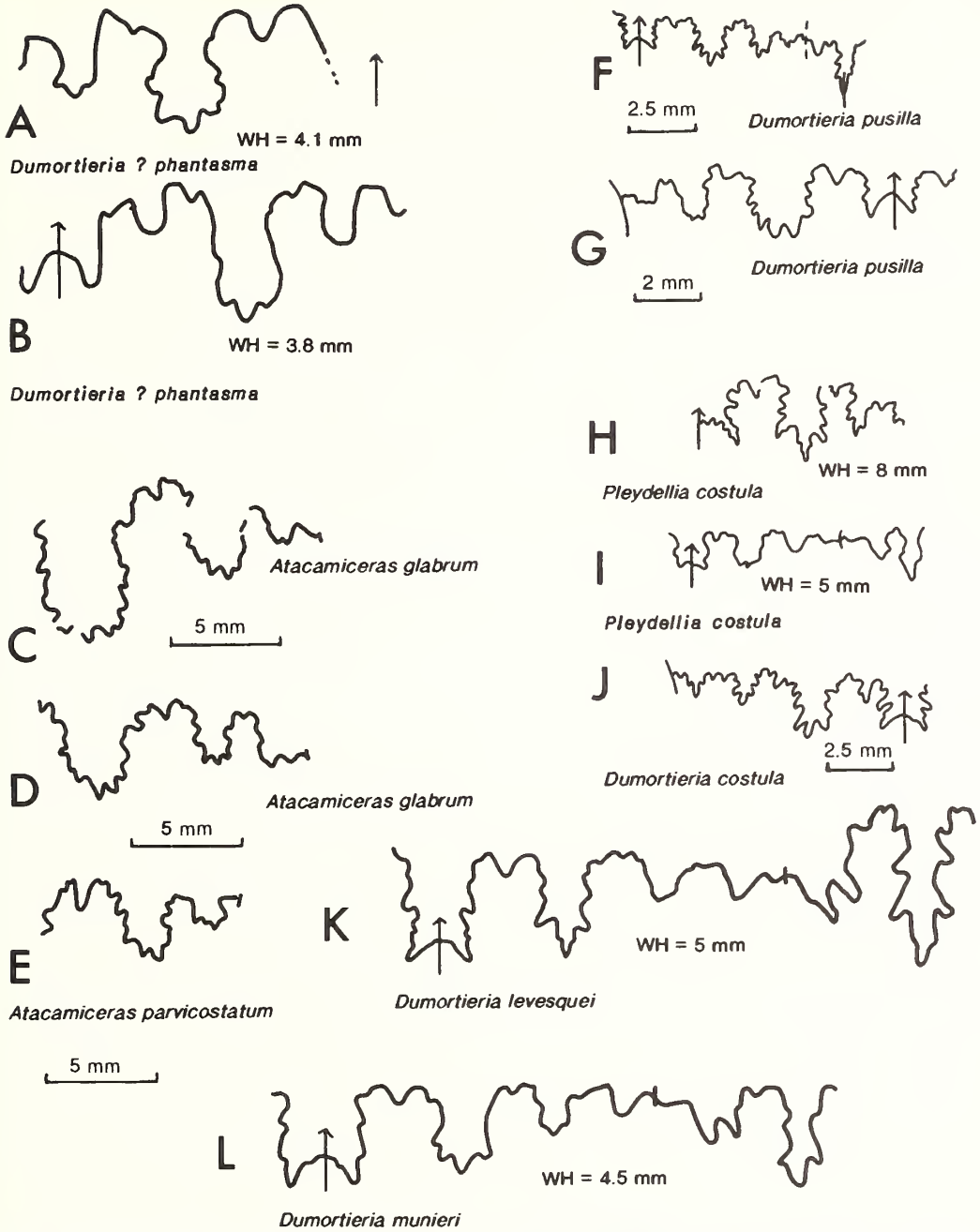
Material. 20 specimens in the sandstones and calcareous concretions of the Phantom Creek Formation, Queen Charlotte Islands (Section 1, loc. 17; Section 2, loc. 17; Section 3, locs 89, 95).

Measurements.	D	UD	U	WH	WW	WWHH	PRHW
GSC 99514	30·5	10·6	34·8	11·5	7·6	0·66	10
GSC 99515	24·7	7·5	30·4	10·4	6·7	0·64	8
GSC 99516	38·8	13·5	34·8	14·2	—	—	—
GSC 107280	19·0	6·7	35·3	7·3	5·0	0·68	7

Description. The moderately evolute shell has a high oval whorl section and shallow umbilicus. The umbilical wall and shoulder are gently sloping. Flanks are gently convex and merge into the venter with weak ventro-lateral shoulders. The venter is carinate. Ribbing density and strength vary. Primary ribs are slightly prorsiradiate to approximately one-third the flank height where, generally, they bifurcate. Secondary ribs are rectiradiate to the ventro-lateral shoulders, then become prorsiradiate and approach, but do not reach, the venter. Intercalatory ribs are common.

Remarks. Théobald and Moine (1959) studied *Pl. aalensis* in an attempt to define this variable species more clearly. They concluded that *Pl. aalensis* could be defined as possessing simple ribs that commonly bifurcate near the umbilical shoulder. The ribs are falciform, rounded and fade toward the venter. The whorl section is oval and the flanks are slightly flattened. The U value averages 31·5 but can range from 27 to 36, and WWWH averages 0·58, but can range from 0·50 to 0·66. Two varieties can be distinguished by ribbing density, a coarsely ribbed *aalensis* type and a densely ribbed *tenuicostata* type.

The North American specimens fall within the range of variability of *Pl. aalensis*, although the ribs tend to bifurcate higher on the flanks than in the holotype. However, the specimen figured by Schlegelmilch (1976, pl. 51, fig. 9) has ribs that bifurcate near mid-flank. *Pl. fluens* (Buckman, 1890) has much finer and dense ribbing. *Pl. subcompta* has fine, dense ribbing which bundles in threes or fives at the umbilical shoulder. *Pl. crassiornata* has a coarser ornament and swollen primary ribs.



TEXT-FIG. 16. Septal suture lines of *Dumortiera*, *Dumortieria*?, *Pleydellia* and *Atacamiceras*. A, GSC 107345; Section 2, loc. 4, Queen Charlotte Islands; B, GSC 107346; Section 2, loc. 4, Queen Charlotte Islands; C, Hillebrandt (1987, pl. 8, fig. 2; text-fig. 2*a*); D, Hillebrandt (1987, pl. 8, fig. 16; text-fig. 2*b*); E, Hillebrandt (1987, pl. 8, fig. 17; text-fig. 2*c*); F, Jaworski (1926, pl. 4, fig. 17); G, Jaworski (1926, pl. 4, fig. 22); H, Schlegelmilch (1976, p. 94); I, Schlegelmilch (1976, p. 94); J, Jaworski (1926, pl. 4, fig. 19); K, Schindewolf (1964, p. 293, text-fig. 178); L, Schindewolf (1964, p. 295, text-fig. 179). WH, whorl height.

Distribution. Pleydellia aalensis is common in the Upper Toarcian Aalensis Zone of Europe (Fischer 1966; Géczy 1967; Goy and Martínez 1990).

Genus DUMORTIERIA Haug, 1885

[= *Catulloceras* Buckman, 1925; *Dactyliogammites* Buckman, 1925; *Phenakoceras* Maubeuge, 1949 (*non* Frech, 1902); *Phenakocerites* Maubeuge, 1950]

Type species. Ammonites levesquei d'Orbigny, 1844 (subsequent designation by Buckman 1890).

Diagnosis. Moderately evolute planulates with ogival whorl sections; umbilical shoulder abrupt to moderately rounded; venter carinate; ribbing almost rectiradiate, becoming slightly prorsiradiate on upper flanks, terminating at venter; ribbing sparse or dense.

Distribution. Dumortieria is found almost world-wide in the Late Toarcian correlatives of the Levesquei Zone (Donovan *et al.* 1981).

Dumortieria insignisimilis (Brauns, 1865)

Plate 3, figures 17, 19

1865 *Ammonites insigni similis* Brauns, p. 106, pl. 5, figs 5–7.
1923 *Dumortieria insignisimilis* (Brauns); Ernst, p. 56, pl. 9, figs 1–3.
1967 *Dmmortieria insignisimilis* (Brauns); Géczy, p. 144, pl. 31, fig. 6.
1993 *Dumortieria* cf. *insignisimilis* (Brauns); Arthur *et al.*, p. 32, pl. 1, figs 11–15.

Material. Five specimens from eastern Oregon (Section 7, loc. 5) where the species is best represented. Poorly preserved specimens from the Queen Charlotte Islands (Section 5, loc. 5) and from Harrison Lake (Arthur *et al.* 1993; Text-fig. 2; Collections 42–43).

Description. The evolute shell bears a low rounded keel. The ribs are wiry and widely spaced, reaching a density of up to 20 per half whorl at umbilical diameters greater than 10 mm. The ribs are rectiradiate across the flank and project onto the venter where they abut directly against the keel.

Remarks. This species is more evolute and less densely ribbed than *D. exacta* Buckman, 1905. *D.* cf. *dumortieri* Thiollière *in* Dumortier, 1874 is more evolute and slowly expanding, and its ribs are more densely spaced and projecting. *D. raricostata* Géczy, 1967 has less rectiradiate, more projecting ribbing.

Distribution. In Europe, *Dumortieria insignisimilis* is known from the Upper Toarcian of Germany (Ernst 1923), Austria (Fisher 1966), Hungary (Géczy 1967) and possibly Spain (de Villalta and Rosell 1966).

Dumortieria cf. *dumortieri* (Thiollière *in* Dumortier, 1874)

Plate 3, figure 16

cf. 1874 *Ammonites dumortieri* Thiollière *in* Dumortier; figured by Roman 1938, p. 105, pl. 9, fig. 96; and Arkell *et al.* 1957, p. 262, fig. 296.
cf. 1892 *Catulloceras dumortieri* (Thiollière); Buckman, p. 277, pl. 39, figs 6–9.
cf. 1964*a* *Catulloceras?* sp. indet.; Frebold, p. 16, pl. 7, figs 5–9.
cf. 1967 *Dumortieria dumortieri* (Thiollière *in* Dumortier); Géczy, p. 137, pl. 30, fig. 8.
1968 *Catulloceras* cf. *C. dumortieri* (Thiollière); Imlay, p. 46, pl. 9, figs 2–4 only.
cf. 1968 *Dmmortieria dumortieri* (Thiollière *in* Dumortier); Setti, p. 329, pl. 30, fig. 3; pl. 31, fig. 1.
cf. 1975 *Catulloceras dumortieri* (Thiollière); Guex, p. 115, pl. 7, fig. 1.

Material. Three small and poorly preserved specimens from east-central Oregon (Section 7, locs 5–6). According to Imlay (1968), it is also present in the Bennett area, northern British Columbia (Text-fig. 2; Collections 16–17).

Description. The evolute shell expands slowly and has convex flanks. The ribbing is sharp, dense, rectiradiate, and only weakly projecting onto the venter.

Remarks. These specimens cannot be identified with confidence because of their small size and poor preservation. They are evolute and finely ribbed but not as markedly as, for example, *D. evolutissima* (Prinz, 1904), and we prefer to compare them with *D. dumortieri* which Imlay (1968) has already reported from Oregon on the basis of larger specimens.

Distribution. Dumortieria dumortieri is widely distributed in the Upper Toarcian of Europe: in Italy from the Meneghinii Zone (Donovan 1958), in Austria from the Aalensis Subzone of the Levesquei Zone (Fischer 1966), and in France from the Levesquei Subzone of the Pseudoradiosa Zone (Guex 1975; Elmi and Rulleau 1991).

Dumortieria cf. *exacta* Buckman, 1905

Plate 3, figure 15

cf. 1892 *Dumortieria subundulata* Buckman, pl. 45, figs 6–7 only.
cf. 1905 *Dumortieria exacta* Buckman, supplement, p. 187.

Material. A single specimen preserved in a siltstone of the Snowshoe Formation, east-central Oregon (Section 7, loc. 5).

Description. A small, moderately evolute specimen (U = 40) bearing a low keel. The ribs are sharp and slightly flexuous on early whorls. Ribbing density increases from 21 ribs per half whorl at an umbilical diameter of 6 mm to 29 at 11 mm.

Remarks. As far as the preservation permits comparison, this specimen is similar to a variant of *Dumortieria subundulata* (Buckman, 1892, pl. 45, figs 6–7) that Buckman (1905) elevated to the rank of species and named *D. exacta.* It differs from all other species of *Dumortieria* described from North America by its densely spaced, fine ribbing which is characteristic of the *pseudoradiosa* group of species, as described by Ernst (1923).

Dumorteria raricostata Géczy, 1967

Plate 3, figures 20–21

1967 *Dumortieria stefaninii* ? *raricostata* n. subsp. Géczy, p. 142, pl. 31, fig. 8.
1968 *Dumortieria raricostata* Geczy; Setti, p. 332, pl. 32, fig. 3.
?1968 *Catulloceras* cf. *C. dumortieri* (Thiollière); Imlay, p. 46, pl. 9, fig. 5 only.

Material. Three specimens, two of them fragments, preserved in a siltstone of the Snowshoe Formation, east-central Oregon (Section 7, loc. 4).

Description. The shell is evolute, secondarily compressed and bears a low rounded keel. The coarse ribs project onto the venter from the uppermost part of the flank; there are 26 ribs on the outer half whorl. Weak constrictions are evident and the figured specimen bears an 8 mm wide collar that shows faint growth lines and a constricted peristome.

Remarks. The figured specimen represents a mature individual, presumably a macroconch although its microconch is unknown. One specimen of *D. raricostata* is known from the Upper Toarcian of Hungary (Géczy 1967) and two from Italy (Setti 1968), but none show evidence of maturity in spite of reaching larger shell diameters than the Oregon specimen.

Dumortieria? *phantasma* sp. nov.

Plate 2, figures 3–7; Text-figure 16A–B

Derivation of name. After Phantom Creek in central Graham Island, Queen Charlotte Islands.

Material. 50 small casts in calcareous concretions and several flattened specimens in shales and siltstones of the Phantom Creek Formation. Queen Charlotte Islands (Section 2, locs 3–5). Also specimens from the Manson River area (Text-fig. 2; Collection 38) and the southern Canadian Rocky Mountains (Collection 45).

Holotype. GSC 99520 (Pl. 2, figs 3–4) from the lower part of the Phantom Creek Formation (Yakounensis Zone), Yakoun River, Queen Charlotte Islands.

Paratypes. GSC 99521 (Pl. 2, figs 5–6), GSC 99522 (Pl. 2, fig. 7)

Measurements.	D	UD	U	WH	WW	WWWH
GSC 99520	23·3	8·4	36·1	8·7	6·1	0·70
GSC 99521	18·6	7·5	40·3	6·5	4·6	0·71
GSC 99522	16·9	8·0	47·3	5·2	3·8	0·73

Diagnosis. Compressed, moderately evolute shell; elliptical whorl section; umbilical wall gently sloping; umbilical shoulder gently rounded; flanks gently convex, converging toward sharp venter; ornament generally weak or absent. On outer whorls of some specimens, there are simple, distant, rectiradiate ribs which fade on outer part of flank.

Description. The holotype, GSC 99520, is a moderately well preserved specimen, septate to 23·1 mm shell diameter with approximately 130° of body chamber ending in an incomplete aperture. The body chamber is slightly crushed. The shell is moderately evolute with a compressed, elliptical whorl section. The flanks are gently convex and converge toward the venter. The venter is sharp but plain. Faint, sparse, rectiradiate ribs are present on the last whorl and fade on the upper part of the flank. The holotype is one of the largest specimens collected, and the sutures on the last part of the phragmocone are approximated. The paratype, GSC 99521, is a moderately well preserved specimen, septate to approximately 5 mm umbilical diameter with approximately 180° of body chamber ending in an incomplete aperture. The body chamber is slightly crushed. The shell has similar features to the holotype. Faint, sparse, rectiradiate ribs are present on the body chamber. The paratype, GSC 99522, is a moderately well preserved specimen, septate to 19·2 mm shell diameter with approximately 100° of body chamber ending in an incomplete aperture. The body chamber is partially crushed.

Remarks. This form shows similarities to *Atacamiceras* and *Dumortieria*. Its ornament and septal suture are similar to the South American genus *Atacamiceras* described by Hillebrandt (1987). *Atacamiceras glabrum* Hillebrandt, 1987 is smooth except for rare mid-flank ribs. *A. parvicostatum* Hillebrandt, 1987 has smooth inner whorls and is ribbed on the last part of the phragmocone and on the body chamber. Both *Atacamiceras* and the North American form have simple septal sutures

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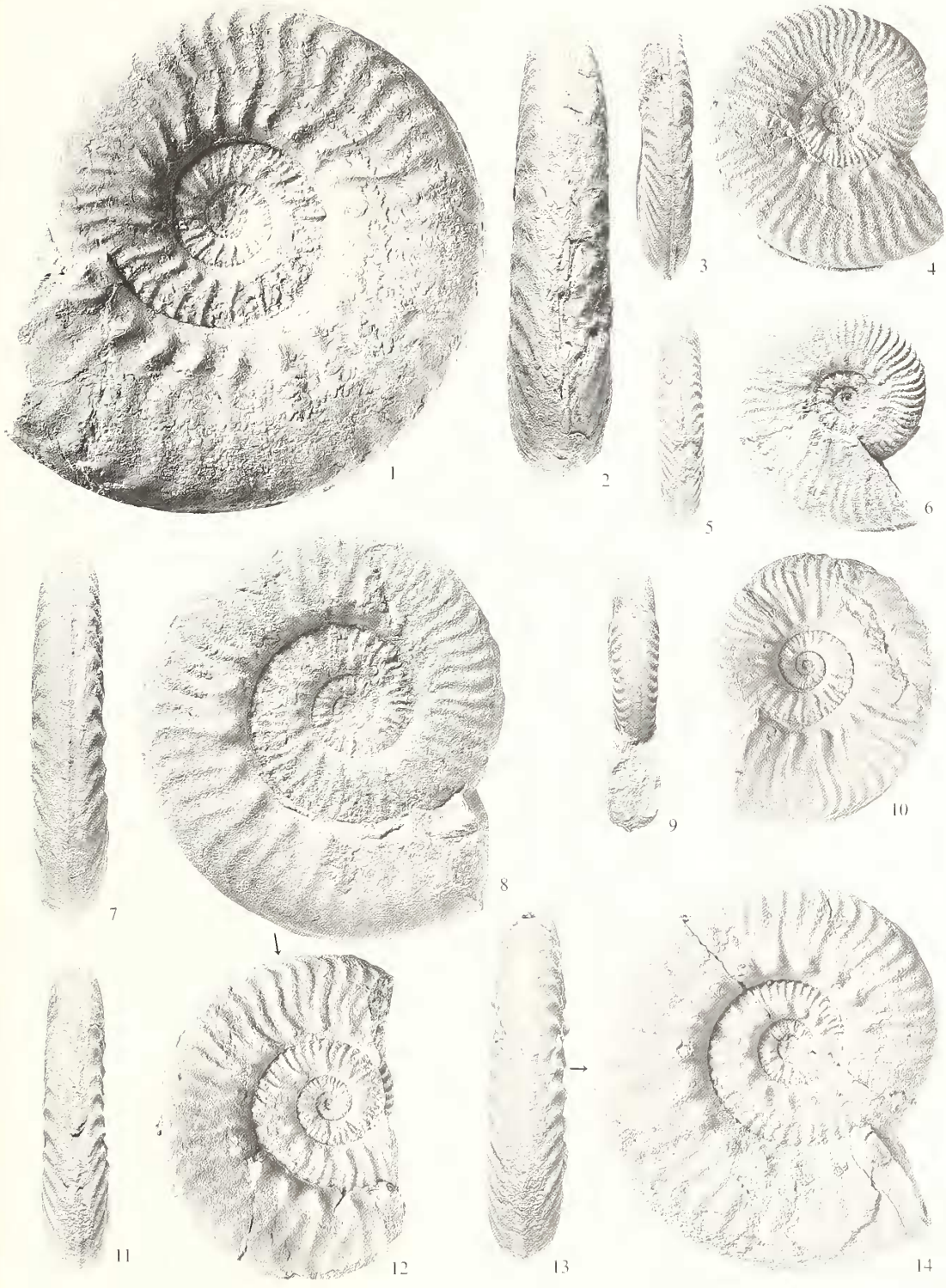
EXPLANATION OF PLATE 4

Figs 1–6, 9–10. *Yakounia silvae* gen. et sp. nov.; Yakounensis Zone, lower part of the Phantom Creek Formation; Queen Charlotte Islands. 1–2, GSC 99525, holotype; GSC Loc. No. C-149652, Section 2, loc. 4. 3–4, GSC 99526, paratype; GSC Loc. No. C-149652, Section 2, loc. 4. 5–6, GSC 99527, paratype; GSC Loc. No. C-149652, Section 2, loc. 4. 9–10, GSC 99528, paratype; GSC Loc. No. C-149652, Section 2, loc. 4.

Figs 7–8, 11–14. *Yakounia yakounensis* gen. et sp. nov.; Yakounensis Zone, lower part of the Phantom Creek Formation; Queen Charlotte Islands. 7–8, GSC 99529, paratype; GSC Loc. No. C-149652, Section 2, loc. 4. 11–12, GSC 99530, paratype; GSC Loc. No. C-149652, Section 2, loc. 4. 13–14, GSC 99531, holotype; GSC Loc. No. C-149652, Section 2, loc. 4.

Arrows mark start of body chamber. All are × 1.



JAKOBS and SMITH, *Yakounia*

(Text-fig. 16). *Dumortieria*? *phantasma* has a more compressed shell whereas *Atacamiceras* has convex flanks. In addition, *Atacamiceras* occurs in the Middle Toarcian of South America whereas the North American form occurs in the latest Toarcian. *Dumortieria*? *phantasma* is also similar to *D. pusilla* which has smooth internal whorls with distant, simple, rectiradiate ribs on the outer whorls (see below). *D. pusilla*, however, has prominent ribbing and achieves it at an earlier stage of development. *D.*? phantasma could be an offshoot of *D. pusilla* via neoteny. The paratype, GSC 99521, displays prominent simple ribs toward the end of the shell, and is similar to the early stages of *D. pusilla*. In addition, the simple septal sutures of *D.*? *phantasma* could represent the early sutures of *D. pusilla*.

Dumortieria? cf. *pusilla* Jaworski, 1926

Plate 2, figures 8, 15–16; Plate 3, figure 18

Material. 75 specimens from limestones, mudstones and siltstones of the Snowshoe Formation, east-central Oregon (Section 7, locs 4–5; Section 8, loc. 1), where the species is best represented. Rare and poorly preserved specimens from the Queen Charlotte Islands (Text-fig. 2; Section 3, loc. 97) and the Spatsizi area (Collection 28).

Description. The shell is moderately evolute bearing a weak keel. The ribbing is distant and simple. The ribs are rectiradiate on the flanks and project onto the venter where they fade. The inner whorls are smooth.

Discussion. Dumortieria pusilla was originally described from Argentina by Jaworski (1926) where it occurs in the South American '*Pleydellia fluitans*' Zone, a correlative of the upper Aalensis Subzone of the European Levesquei Zone, according to Hillebrandt (1987). Plaster copies of Jaworski's (1926) type material are figured in Plate 2, figures 9–10 and 13–14. The species is characterized by its smooth inner whorls, a feature that distinguishes it from other species of *Dumortieria* which, at most, have only a small smooth nucleus.

The generic assignment of *Dumortieria pusilla* is based on the simple, distant ribs which characterize many other *Dumortieria* species, such as *D. levesquei* (d'Orbigny, 1844), *D. insignisimilis* and *D. striatulocostata* (Quenstedt, 1885). No other *Dumortieria*, however, possesses smooth internal whorls to such large shell diameters.

Family PHYMATOCERATIDAE Hyatt, 1867
Subfamily PHYMATOCERATINAE Hyatt, 1900

Genus YAKOUNIA gen. nov.

Derivation of name. After the Yakoun River, central Graham Island, Queen Charlotte Islands where Toarcian outcrops are most abundant.

Type species. Yakounia yakounensis sp. nov.

EXPLANATION OF PLATE 5

Figs 1–2. *Yakounia freboldi* gen. et sp. nov.; GSC 99532, holotype; Yakounensis Zone, lower part of the Phantom Creek Formation; Queen Charlotte Islands, GSC Loc. No. C-156390, Section 1, loc. 17.

Figs 3–6. *Yakounia yakounensis* gen. et sp. nov.; Yakounensis Zone, lower part of the Phantom Creek Formation; Queen Charlotte Islands. 3–4, GSC 107258, paratype; GSC Loc. No. C-149652, Section 2, loc. 4. 5–6, GSC 107259, paratype; GSC Loc. No. C-149652, Section 2, loc. 4.

Figs 7–8. *Holcophylloceras calypso* (d'Orbigny); GSC 107260; Yakounensis Zone, lower part of the Phantom Creek Formation; Queen Charlotte Islands, GSC Loc. No. C-87221, Section 2, loc. 17.

All are × 1.

JAKOBS and SMITH, *Yakounia* and *Holcophylloceras*

Diagnosis. Moderately evolute shell; ogival whorl section; umbilical wall gently sloping; umbilical shoulder rounded; flanks moderately flat, converging toward a carinate venter with weak ventrolateral shoulders. Venter on inner whorls may be weakly carinate-sulcate. Ornament distinctive, consisting of gently sinuous to approximately rectiradiate ribs that arise in twos or threes from strong umbilical tubercles or prorsiradiate bullae.

Remarks. This form can be compared with several genera of the Phymatoceratinae. According to Donovan (1958), *Brodieia* has sigmoidal ribs joined in groups of two or more to umbilical tubercles. *Brodieia* can be differentiated from *Phymatoceras* and *Haugia* by its non-septate keel. *Yakounia* possesses a septate keel, is more evolute, and the umbilical tubercles are more regular and prominent than in *Brodieia*. *Haugia* has a tall keel, and the ribs and tubercles tend to fade on the outer whorls. In addition, the ribs tend to be more rectiradiate. *Yakounia*'s keel is more subdued, the ornament is prominent on the outer whorls, and the ribs are generally more sinuous and project along the venter. *Phymatoceras* is similar, especially such species as *P. copiapense* and *P. hillebrandti*. In general, however, *Yakounia* has stronger tuberculation, shallower sulci, and a more gently rounded umbilical shoulder. *Yakounia*, especially *Y. pacifica* which has a pronounced angular bend of the ribs low on the flanks, may have evolved into *Ludwigia* or some of the Graphoceratidae.

Distribution. The genus is Late Toarcian in age, occurring with *Hammatoceras*, *Dumortieria*, *Sphaerocoeloceras* and *Pleydellia*. It has been collected from the Queen Charlotte Islands, the Fernie area, southern Alaska, and possibly the Spatsizi area.

Yakounia yakounensis sp. nov.

Plate 4, figures 7–8, 11–14; Plate 5, figures 3–6

1976 *Haugia* aff. *H. navis* (Dumortier); Frebold, p. 14, pl. 7, fig. 3.
1981 *Haugia* cf. *variabilis* (d'Orbigny); Imlay, p. 43, pl. 12, figs 1–2, 5.
v 1987 ?Grammoceratinae gen. et sp. indet., Hall, p. 1702, pl. 5, figs N–O.

Derivation of name. After the Yakoun River, central Graham Island, Queen Charlotte Islands where Toarcian outcrops are most abundant.

Material. 60 specimens from calcareous concretions and sandstones of the Phantom Creek Formation, Queen Charlotte Islands where the species is best represented (Section 1, loc. 17; Section 2, locs 3–6, 17; Section 3, locs 89, 105; Section 4, locs 2, 4, 6, 14; Section 5, locs 2, 5). Also specimens from the Talkeetna Mountains (Text-fig. 2; Collections 5, 9), the Spatsizi area (Collections 21, 26), and the southern Canadian Rocky Mountains (Collection 45).

Holotype. GSC 99531 (Pl. 4, figs 13–14) from the lower part of the Phantom Creek Formation (middle Yakounensis Zone), Yakoun River, Queen Charlotte Islands.

Paratypes. GSC 99529 (Pl. 4, figs 7–8), GSC 99530 (Pl. 4, figs 11–12), GSC 107258 (Pl. 5, figs 3–4), GSC 107259 (Pl. 5, figs 5–6), GSC 107281–107283

Measurements.	D	UD	U	WH	WW	WWWH	PRHW
GSC 99531	64·0	28·0	43·8	19·6	12·3	0·63	10
GSC 99531	50·4	20·0	39·7	17·7	10·7	0·60	9
GSC 99529	65·8	32·4	49·2	17·7	13·0	0·73	11
GSC 99529	54·0	24·7	45·7	17·0	10·5	0·62	10
GSC 107259	40·5	15·8	39·0	15·0	8·5	0·57	10
GSC 107259	33·8	12·0	35·5	13·0	*c.* 6·6	*c.* 0·51	10
GSC 107281	54·0	22·4	41·5	17·3	11·6	0·67	10
GSC 107282	68·3	34·0	49·8	20·2	14·7	0·73	12
GSC 107282	53·6	25·0	46·6	16·0	11·2	0·70	10
GSC 107283	110·1	47·5	43·1	36·4	20·7	0·57	13

Diagnosis. Moderately evolute shell; ogival whorl section; umbilical wall gently sloping; umbilical shoulder rounded; flanks flat to gently convex; venter carinate-sulcate on inner whorls becoming carinate on outer whorls; ornament distinctive, consisting of sharp umbilical tubercles from which two to three secondary ribs proceed up the flanks with a gently sinuous trend.

Description. The holotype, GSC 99531, is a well preserved specimen, septate to 55·8 mm shell diameter with approximately 90° of body chamber ending in an incomplete aperture at 64·0 mm shell diameter. The specimen is cracked and a small part of the venter is absent. The shell is moderately evolute with a compressed ogival whorl section. The umbilical wall is gently dipping and the umbilical shoulder is rounded. The flanks are flat to slightly convex and converge toward the carinate venter. The ornament consists of sharp, prominent tubercles at the umbilical shoulder from which two to three secondary ribs proceed up the flank with a gently sinuous trend and terminate at the ventro-lateral shoulder. The tubercles are slightly prorsiradiate and are more prominent on the outer whorls. The paratype, GSC 99530, is a moderately well preserved specimen, septate to 24·6 mm umbilical diameter, with approximately 180° of body chamber ending in an incomplete aperture at approximately 52 mm shell diameter. The specimen is broken on one side. The shell is moderately evolute with a compressed, ogival whorl section. The umbilical wall is gently dipping and the umbilical shoulder is rounded. The flanks are flat to gently rounded. The venter is carinate-sulcate on the inner whorls becoming carinate on the outer whorls. The tubercles at the umbilical shoulder are slightly prorsiradiate and give rise to two or three gently sinuous ribs. The paratypes, GSC 99529 and GSC 107259, are moderately well preserved with parts of their body chambers but incomplete apertures. The body chamber of the latter is slightly crushed. The paratype, GSC 107258, is a moderately well preserved specimen with approximately 230° of body chamber ending in an incomplete aperture. The shell is cracked, slightly crushed and part of the nucleus and venter are absent. The shell is moderately evolute with an ogival whorl section. The whorl section is less compressed than in the previous forms and GSC 107282 has a similar shape. The tubercles at the umbilical shoulder are prominent, sharp and slightly prorsiradiate.

Remarks. This species is distinctive and easily recognized because of its prominent, pointed umbilical tubercles and the gently sinuous ribs. Imlay (1981) compared the southern Alaskan specimens to *Hangia variabilis*, but he noted that they were more evolute and more sparsely ribbed on the outer whorls. He also noted that the holotype of *H. japonica* (Neumayr, 1875) as figured by Kobayashi (1935, pl. 12, figs 3–4) had a much weaker ornament. He compared the southern Alaskan speciments to *Hangia* aff. *japonica* figured by Matsumoto and Ono (1947, pl. 2, fig. 5) but that specimen has much weaker tuberculation, that fades on the outer whorl, and sigmoidal ribbing; it is possibly *Phymatoceras hillebrandti*.

Yakounia yakounensis is distinguished from other species by its prominent umbilical tubercles. *Y. freboldi* sp. nov. has thick, distant ribs with prorsiradiate bullae. *Y. pacifica* sp. nov. has a prominent angular flexure of the ribs, and the ribs and tubercles are subdued. *Y. silvae* sp. nov. is an intermediate form which has characteristics of all three. It possesses tubercles similar to *Y. freeboldi*, but the ribbing density is similar to that of *Y. yakounensis*.

Yakounia freboldi sp. nov.

Plate 5, figures 1–2; Text-figure 15c

Derivation of name. After Dr H. Frebold who, for many years, was the Jurassic palaeontologist of the Geological Survey of Canada.

Material. Nine specimens in calcareous concretions and sandstones of the Phantom Creek Formation, Queen Charlotte Islands (Section 1, loc. 17; Section 2, loc. 4; Section 3, loc. 89; Section 4, locs 2, 4, 6; Section 5, locs 2, 5). Also from the southern Canadian Rocky Mountains (Text-fig. 2; Collection 47).

Holotype. GSC 99532 (Pl. 5, figs 1–2) from the lower part of the Phantom Creek Formation (Yakounensis Zone), Yakoun River, Queen Charlotte Islands.

Paratypes. GSC 107284–107287

Measurements.	D	UD	U	WH	WW	WWWH	PRHW
GSC 99532	129·4	57·4	44·4	42·4	30·0	0·71	13
GSC 99532	109·0	48·6	44·6	35·8	25·0	0·70	14
GSC 99532	100·3	44·0	43·9	29·9	20·5	0·69	14
GSC 99532	—	31·3	—	25·5	16·2	0·64	11
GSC 107284	86·0	35·6	41·4	28·3	19·2	0·68	10
GSC 107284	65·8	27·0	41·0	23·1	14·5	0·63	10
GSC 107285	98·0	43·3	44·2	31·1	*c.* 19·1	*c.* 0·61	11
GSC 107285	88·4	37·0	41·9	30·7	*c.* 15	*c.* 0·49	11
GSC 107285	78·4	32·7	41·7	19·6	11·7	0·60	8
GSC 107286	81·6	30·5	37·4	28·5	19·5	0·68	11
GSC 107287	49·2	16·7	33·9	19·6	11·7	0·60	8
GSC 107287	43·1	14·4	33·4	17·6	11·2	0·64	8

Diagnosis. Moderately evolute shell; ellipsoidal to rectangular whorl section; venter carinate-sulcate on inner whorls becoming carinate on outer whorls; ornament coarse, consisting of prorsiradiate bullae on lower flank from which two to three secondary ribs arise.

Description. The holotype, GSC 99532, is a well preserved specimen with more than 360° of body chamber ending in an incomplete aperture at 129·4 mm shell diameter. Part of the venter is broken away on a small segment of the body chamber. The shell is moderately evolute with a rectangular to ellipsoidal whorl section. The umbilical wall is gently sloping, and the umbilical shoulder is rounded. The flanks are flattish to gently convex. The venter is carinate with weak ventro-lateral shoulders. The ornament is coarse. On the inner whorls, umbilical tubercles give rise to two or three gently sinuous ribs. During ontogeny, the tubercles lengthen into prorsiradiate bullae which give rise to two or three sinuous ribs. The ribs are strongly projecting along the ventro-lateral shoulder and occasionally may reach the venter where subdued swellings are sometimes seen on well preserved parts of the body chamber. The paratype, GSC 107286, is a moderately well preserved specimen wholly septate to a shell diameter of 87·0 mm. The shell is cracked and parts of the phragmocone have broken off. The inner whorls are not exposed. The shell is moderately evolute with a rectangular to ellipsoidal whorl section. The umbilical wall is gently sloping and the umbilical shoulder is rounded. The flanks are flattish, and the venter is carinate with rounded ventro-lateral shoulders. The ornament is coarse with prorsiradiate umbilical bullae, commonly giving rise to two sinuous ribs at approximately one-quarter the flank height. The ribs are strongly projecting along the ventro-lateral shoulder and, where the specimen is well preserved, may reach the venter, where subdued swellings are seen. The other paratypes are not as well preserved but all have similar features to the other types.

Remarks. This species has a coarser ornament than *Yakounia yakounensis*, and the bullae are not as sharp. The inner whorls are similar to *Phymatoceras copiapense* and *Ph. hillebrandti*, which may have been ancestors. *Y. freboldi* may, in turn, be ancestral to *Ludwigia*. The inner whorls have almost straight ribs and sharp tubercles. On the outer whorls, the ribs become more sigmoidal and the tubercles more elongated. The ornament on the outer whorls is similar to that on the inner whorls of species of *Ludwigia* but, in general, that genus has coarser, more sigmoidal ribbing, elongated bullae or primary ribs, and a less sulcate venter.

Yakounia pacifica sp. nov.

Plate 6, figures 1–2

Derivation of name. After the Pacific Ocean, along the north-eastern shore of which the genus is found.

Material. Three specimens in calcareous concretions and sandstones of the Phantom Creek Formation, Queen Charlotte Islands (Section 2, loc. 4).

Holotype. GSC 107261 (Pl. 6, figs 1–2) from the lower part of the Phantom Creek Formation (Yakounensis Zone), Yakoun River, Queen Charlotte Islands.

Paratype. GSC 107288

Measurements.	D	UD	U	WH	WW	WWWH	PRHW
GSC 107261	113·4	44·7	39·4	37·5	24·6	0·66	12
GSC 107261	102·7	39·9	38·9	36·0	22·0	0·61	12
GSC 107261	89·5	32·7	36·5	33·6	20·0	0·60	13
GSC 107288	78·4	29·5	37·6	28·3	*c.* 15·1	*c.* 0·53	12
GSC 107288	65·8	21·6	32·8	24·4	—	—	11

Diagnosis. Moderately evolute shell; compressed, ogival whorl section; venter carinate-sulcate; ornament prominent, consisting of thick, prorsiradiate primary ribs that split into two or three sinuous secondary ribs low on flanks.

Description. The holotype, GSC 107261, is a moderately well preserved specimen septate to approximately 88 mm shell diameter with approximately 180° of body chamber ending in an incomplete aperture at 113·4 mm shell diameter. The specimen is slightly worn in places. The shell is moderately evolute with an ogival whorl section. The umbilical wall is gently sloping, and the umbilical shoulder is rounded. Flanks are flat, ventrolateral shoulders weak, and the venter carinate. The ornament consists of prorsiradiate primary ribs on the inner whorls that begin high on the umbilical wall. Some ribs may remain single but most bifurcate at approximately one-third the flank height. On the outer whorls, the primary ribs swell into bullae. The paratype, GSC 107288, is a moderately well preserved specimen ending in an incomplete aperture at 78·7 mm shell diameter. The specimen is slightly worn and one side is not exposed. Its morphology is similar to that of the holotype. Septal sutures are present.

Remarks. This species shows some similarity to certain Graphoceratidae such as *Ludwigia* (*Pseudographoceras*) (see Schlegelmilch 1976, pl. 12, figs 5, 7) in terms of whorl shape and ribbing style. However, the Graphoceratidae tend to have a sharp angular flexure of the ribs on the lower flank; this feature is less prominent in similar forms, such as *Phymatoceras hillebrandti*, *Yakounia freboldi*, and *Y. yakounensis*. The Graphoceratidae also tend to be more involute than the Phymatoceratidae although it is possible that they did evolve from them.

Yakounia silvae sp. nov.

Plate 4, figures 1–6, 9–10; Plate 6, figures 3–4

1969 *Phlyseogrammoceras* aff. *P. dispansum* (Wunstorf); Frebold *et al.*, p. 20, pl. 1, figs 10–15.
1987 ?Grammoceratinae gen. et sp. indet., Hall, p. 1702, pl. 5, figs K–L, Q.

Derivation of name. After the thick, old-growth forests that cover(ed) the Queen Charlotte Islands (Latin *silva*, wood, forest).

Material. Over 100 specimens in calcareous concretions and sandstones of the Phantom Creek Formation, Queen Charlotte Islands (Section 1, locs 4–5, 7–8, 17; Section 2, locs 1–6, 8, 10–11, 17; Section 3, locs 89–92, 105; Section 4, locs 1–2, 4, 6–8, 10, 14; Section 5, locs 2–3, 5; Section 6, locs 1–2). Also specimens from the Manson River area (Text-fig. 2; Collection 38), in the Manning Park area (Text-fig. 2; Collection 44), and in the southern Canadian Rocky Mountains (Collection 45).

Holotype. GSC 99525 (Pl. 4, figs 1–2) from the lower part of the Phantom Creek Formation (Yakounensis Zone), Yakoun River, Queen Charlotte Islands.

Paratypes. GSC 99526 (Pl. 4, figs 3–4), GSC 99527 (Pl. 4, figs 5–6), GSC 99528 (Pl. 4, figs 9–10), GSC 107262 (Pl. 6, figs 3–4), GSC 107289–107291